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A SUMMARY OF
FURTHER RESEARCH INTO THE
ECONOMICS OF MILK PRODUCTION
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Foreword

RESEARCH into the economics of milk production in England and Wales is undertaken by the university departments of agricultural economics at certain universities. This national investigation is sponsored and financed jointly by the Ministry of Agriculture, Fisheries and Food, and the Milk Marketing Board. The results of the studies are published from time to time in various journals and in university reports. The purpose of this publication is to present a factual review of the results of various research projects undertaken during the years 1962-65, grouping together studies on similar topics, and to provide a wider circulation of this information for the benefit of farmers, their advisers and agricultural students.

This publication has been prepared by Mr V. H. Beynon, B.Sc.(Hons.) (Agric. Econ.) of the University of Exeter on behalf of the Conference of Provincial Agricultural Economists. The studies were independently conducted by the various universities, and the responsibility for the conclusions which emerge rests with the authors of the reports.

A review of the research projects undertaken during 1957-60 was published in 1963.

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Ministry of Agriculture, Fisheries and Food
July, 1967

Introduction

This is the third report in a series which summarizes the research work undertaken by university departments of agricultural economics in the research periods of the National Investigation into the Economics of Milk Production. The earlier reports dealt with the work carried out during the 1952-55 and 1957-60 research periods. The second period was followed by two years of costings and then by a further three-year period of free research. This report summarizes the research studies carried out during the third research period between 1962 and 1965.

The research programmes of the universities in this period dealt with many aspects of milk production, and, with feedingstuffs so important in total costs, it is not surprising that this item received a great deal of attention in the studies summarized in this report. The first two sections are devoted to factors to consider in choosing a feeding system, and profitability factors. The first section includes a discussion of the role of grassland in milk production. These are followed by a section on budgetary control and Linear Programming in dairying. A final section deals with some national considerations of current interest to milk producers.

1. Factors in choosing a feeding system, including the role of grassland

RESULTS of similar studies undertaken in different parts of the country may often be in conflict because of the impact of environmental and other conditions. However, it is still true to say that wherever milk cost surveys are undertaken in this country, the results all underline the outstanding importance of feed, especially purchased concentrates, in total costs. It is appropriate, therefore, to begin this report with an examination of the factors which influence the choice of a feeding system, including the role of grassland in milk production.

PHYSICAL RELATIONSHIPS BETWEEN MILK YIELDS AND FEED CONSUMED

For a very long time advisers and farmers have used the starch and protein equivalents of different feedingstuffs in compiling rations for livestock, in spite of strong evidence that the effectiveness with which feedingstuffs are utilized varies according to (i) the combination of foods in the ration, (ii) the use made of the ration (maintenance or the production of milk, meat or wool) and (iii) the animals consuming the ration. There is now a distinct possibility that this traditional system will be replaced by the metabolizable energy system. It has been claimed that such a development could result in far more precision in forecasting the milk yield of a dairy cow from data on the nature of the foods fed and the environmental conditions. The new system has already been used at Wye College[2] to devise feeding systems based on high quality forages.

It now appears that as the lactation continues and milk yield falls then the proportion of concentrates in the diet can be reduced, allowing forage to make a greater contribution. The implications of this can be illustrated. For instance, if forage was fed to provide maintenance and the first half gallon of production during the first nine weeks of the lactation, then the same quantity of forage could be expected to provide maintenance and two gallons by the twentieth week. It has been appreciated for some time that response to concentrate feeding is greater in the early stages of a lactation and many farmers tend to feed heavily at this time, thereafter reducing concentrates quite severely.

ECONOMIC IMPLICATIONS OF CHANGES IN COSTS OF STARCH FROM DIFFERENT SOURCES

Barley is now accepted as a source of energy for ruminants. This, combined with the remarkable advances in barley yields over the years, now make the crop attractive in relation to conserved grass and even grazing. Indeed there is ample evidence that the crop is being used as a substitute for hay and silage. But farmers are advisedly treading these new paths very carefully in the initial stages because there is a marked absence of data on the implications of high level concentrate feeding to dairy cows. The only controlled experiments specifically designed to study forage/concentrates substitution in milk production have been carried out by Heady *et al.* at Iowa, U.S.A. in 1953/54 and in 1956/59. Beynon and Langley[3] used the results of the Iowa experiments to emphasize important considerations in the forage versus concentrates controversy in milk production. For example, they calculated that, with hay at £5 per ton, margin over feed costs per cow falls as more concentrates are used to replace the relatively cheap hay. However, the fall in margin is not sufficiently steep to outweigh the advantage of keeping more cows on a given total quantity of hay. With the assumptions made and the experimental data used there are still distinct possibilities of making additional profits by using concentrates and increasing stocking rates. The following table illustrates this quite clearly for situations where forage is strictly limited and concentrates are readily available.

TABLE I

Total feed costs, milk returns and margins over feed costs for different numbers of cows kept on a fixed amount of hay

Feed combination per cow		Marginal* substitution rates	Cows which can be kept on 10 tons hay	Feed costs per herd			Value of milk per herd†	Margin over feed cost	
Concentrates	Hay			Concentrates at £30 per ton	Hay at £5 per ton	Total		Per cow	Total
lb	lb		No.	£	£	£	£	£	£
160	752	3·00	29·8	63·8	50·0	113·8	348·7	7·88	234·9
180	692	2·92	32·4	78·1	50·0	128·1	379·1	7·75	251·0
200	636	2·84	35·2	94·3	50·0	144·3	411·8	7·60	267·5
220	580	2·77	38·6	113·9	50·0	163·9	451·6	7·45	287·7
240	524	2·71	42·7	137·1	50·0	187·1	499·6	7·32	312·5
260	472	2·65	47·5	165·3	50·0	215·3	555·8	7·17	340·5
280	416	2·59	53·8	201·8	50·0	251·8	629·5	7·02	377·7
300	364	2·53	61·5	247·2	50·0	297·2	719·5	6·87	422·3

* This is the rate at which hay substitutes for concentrates when a particular feed combination is fed. For instance, with a ration of 160 lb of concentrates and 752 lb of hay, 3 lb of hay replaces 1 lb of concentrates. With more concentrates and even less hay in the combination, less hay is required to replace 1 lb of concentrates.

† 800 lb of milk per cow at 3s., per gallon.

The above data are, of course, based on Iowa conditions and similar work is needed for this country. They suggest, however, that the use of more expensive rations using concentrates instead of hay makes little difference to total margin over feed cost per cow. There are, therefore, distinct possibilities of moving from one extreme of high yield—high concentrates systems, to low yield and heavy dependence on forage crops at the other, without marked changes in profits per cow. Yet such changes in feeding practices can have an appreciable effect on the size and hence the overall profitability of the herd when the availability of forage grown on the farm is limited.

THE VARYING DEMANDS OF DIFFERENT SYSTEMS OF MILK PRODUCTION

Different systems of milk production make varying demands on farm resources. For example, where acres and forage supplies are the limiting factors to increasing production rather than livestock accommodation, farmers can and do increase their herds by substituting concentrates for forage. As already indicated in the interpretation of Iowa data, this substitution of concentrates for forage may involve a diminishing margin over concentrates per cow. But so long as the value of milk from each additional cow is greater than the cost of the additional concentrates, then total margin over feed costs continue to rise.

Seasonality also influences the choice of a feed system. An extreme summer milk production policy means little or no production during the winter months and consequently the emphasis on conservation can be minimal. On the other hand, availability of arable by-products in the eastern areas are a major factor in inducing farmers to concentrate on winter milk production.

The choice of feed system is not, however, determined solely on the basis of its narrow economic attractions. It is also influenced by such factors as the capital available, the labour involved, the nature, extent and accessibility of the accommodation for dairy cows in relation to land, as well as by the skills and preference of the management and the resultant size of the business.

MEASURING THE OUTPUT OF GRAZING

A number of different methods have been used to measure the productivity of grassland, but few if any are entirely satisfactory. For experimental work the grass can be harvested and its dry matter content determined. The environment can also be controlled and the influence of one factor applied at different levels can be studied while all other factors are held constant. Such techniques can provide accurate measures of the impact of various factors on grassland productivity but the results are not applicable generally. The survey method, on the other hand, has the advantage of relating to the real world. Here many factors are influencing the level of output and many different methods are used to measure output. Utilized Starch Equivalent, cow grazing day equivalents and gallons of milk or pounds liveweight gain are quite commonly employed. The wide range of measures are indications of the different ways grass is utilized. It can be used for maintenance of different livestock and for the production of meat, milk and wool. It can be harvested as dried grass, hay or silage and stored in a host of different containers from the crudest hole in the ground to the most sophisticated glass-lined airtight tower silos. It is also grown under a wide range of soil and climatic conditions. It is not surprising, therefore, that the results recorded from grassland utilization studies exhibit marked variability.

A step forward in overcoming some of the difficulties has been taken by Cowling[4] in an analysis of data relating to 456 fields in a sample of 64 Cheshire dairy farms which were included in a N.A.A.S. Grassland Recording Scheme undertaken in 1961. He measured output in terms of milk production per grassland acre. This measure is influenced by the output of grass, its utilization, the proportion of grass used for purposes other than grazing as well as the level of supplementary feeding. There are obvious difficulties involved in the direct measurement of some of these factors and, therefore, Cowling included a number of variables thought to have an important influence on them.

Using refined statistical techniques, Cowling established the relationship which existed between the dependent variable (milk output per acre) and the following set of seven explanatory variables:

current dosage nitrogen (units per grazing acre)
current dosage phosphate (units per grazing acre)
current dosage potash (units per grazing acre)
stocking rate (cow days per grazing acre)
hay conserved (tons per grazing acre)
silage conserved (tons per grazing acre)
cow concentrates fed (cwt per grazing acre)

The relationship between the dependent variable and the explanatory variables was assumed to be a straight-line one. The author quoted the results of work on nitrogen application to support this assumption. He further claimed that in the data analysed there were in fact no extreme values so that, if non-linear relationships did exist, the resulting bias is minimized. It was found that 87 per cent of the variation in milk output per acre for the 456 fields was explained by the seven variables. Only with two of the variables—current phosphate and potash dosages—could no significant relationship be established with milk output per acre.

The nitrogen coefficient which was obtained showed that the marginal productivity of 1 unit applied to grassland was 0.222 gallons of milk. At current prices for nitrogen the break-even point for the summer milk price would be 34.23d. per gallon which is considerably above the prices now ruling in the summer months. The author suggested that more information was required about the relationship of nitrogen use to quantity of forage conserved, and about the possibility that the extra forage produced may not be used because of understocking. The effects of weather in a particular year also need to be investigated.

Stocking rate was found to be extremely significant in determining milk output per acre. An increase of 50 per cent in stocking rate from the average of 120 cow days per acre to 180, increased milk output from 301 to 413 gallons per acre, an increase of more than a third.

In this study, coefficients for both hay and silage were statistically significant but in both cases were very small. This means that at the level of silage making and haymaking found on this sample of essentially grazing fields, the opportunity cost of silage and hay was very low in terms of the summer milk sacrificed, e.g., for every extra ton of silage made, milk output per acre from grazing was only reduced by 3½ gallons. It would seem, therefore, that silage and hay are only slightly competitive with grazing under the conditions described.

Cowling also examined the perennial topic of response to concentrate feeding when cows were out on grass. He found that his data conflicted with some previously published work. A marginal productivity of 1 gallon for an addition of 8 lb of concentrates, assuming a price of £30 per ton of concentrates gave a break-even price of 25.30d. per gallon, which is below the summer prices ruling in recent years. Since a cheaper, more starchy, concentrate ration could be used, it would suggest that concentrate feeding was still worth while on these farms whilst the cows were out on grass.

PERFORMANCE FROM GRAZING

Studies of spring and autumn patterns of milk production have all emphasized the importance of performance from grazing and conserved grass products in determining profits. They have also drawn attention to the serious gaps in our knowledge of milk production levels that can be sustained from grass. Consequently much of the work on seasonality undertaken by the University of Exeter has been based on the estimates of the levels of performance from grass shown in Table 2.

TABLE 2

*Milk yields from grazing**

	Average	Above average
	gallons per day	
April	2	2
May	3	4
June	3	4
July	2½	3
August	2	2½
September	1	1½

* Maintenance plus so many gallons
1 gallon = 10·32 lb

Langley[5] considered that it was not easy to establish the validity of these assumptions from herd data because calving took place over an extended period of time in the majority of herds and the average results do not clearly reflect the detailed management and levels of performance achieved by individual cows. The main objective of his study was to ascertain whether or not the average and above average levels of performance from grazing set out above were realistic standards for budgetary purposes.

The weekly milk yield and concentrates fed during the lactation of 96 spring-calving cows were individually recorded for 1964/65. Most of the cows were Friesians calving in February and March but, in addition, 19 Ayrshires and 5 Shorthorns were also recorded. The results of the investigation have been presented for seven four-weekly periods, covering the 6 months from April to October. The average results for the 96 cows were as follows:

TABLE 3

Average performance from grazing 1964/65

(*based on* 96 *cows, Exeter Province*)

Period	*Total milk yield*	*Concentrates fed* lb per cow (daily)	*Estimated milk yield from grazing*
5 Apr — 2 May	48	11	25*
3 May — 30 May	48	6	32
31 May — 27 Jun	42	5½	28
28 Jun — 25 Jul	38	5½	24
26 Jul — 22 Aug	34	5½	20
23 Aug — 19 Sep	29	6¼	12
20 Sep — 17 Oct	24	6	8

* For that part of the four weeks during which cows were at pasture. During the peak of the grazing season in May and June over 90 per cent of the cows still received concentrates.

These average figures concealed a wide range in the performance of individual cows, and as such they are only of limited use in indicating the levels of production possible from grazing. To overcome this, the results of the 10 Friesian cows with the highest output from grazing have been extracted and set out in the following table.

TABLE 4

Performance from grazing

(10 *Friesian cows with the highest output from grazing*)

Period	*Total milk yield*	*Concentrates fed* lb per cow (daily)	*Estimated milk yield from grazing*
5 Apr — 2 May	57	7½	44*
3 May — 30 May	54	1½	50
31 May — 27 Jun	48	½	47
28 Jun — 25 Jul	44	½	43
26 Jul — 22 Aug	38	—	37
23 Aug — 19 Sep	31	1½	26
20 Sep — 17 Oct	26	4	15

* For that part of the four weeks during which cows were at pasture.

This study indicated the contribution which grazing could make in milk production and suggested that there was considerable overfeeding of dairy cows with concentrates during the summer months. This was in agreement with experimental results which have drawn attention to the low response to supplementary feeding of concentrates to dairy cows on grazing.

Finally the author stated that 'the supplementary feeding of dairy cows at pasture cannot be considered without due regard to the level of stocking. However, the higher levels of milk output from grazing in this study did not appear to be associated with greater acreage requirements.'

THE CHOICE OF CONSERVATION TECHNIQUE

The intensity with which techniques of conserving grass have been discussed in the post-war period has varied according to the availability and cost of purchased concentrates. For many years the low cost of nutrients in hay and silage, as well as the heavy losses incurred in conservation have been uppermost in the minds of most grassland enthusiasts. It is not surprising, therefore, to find conservation methods being constantly varied, modified and adapted in an effort to overcome disadvantages and exploit advantages. Current estimates of losses vary widely, but it is generally accepted that as much as one-third of the original nutrients may be lost during conservation and storage. These losses have two major implications. In the first place expensive concentrates have to be used to make up for deficiencies in home-grown forages and secondly the low quality of forage may restrict total intake of nutrients with serious repercussions on yields.

It has been claimed that various techniques are now available, all of which help farmers to harvest a product of higher quality without the fluctuations which are usual from year to year. A carefully planned sequence of various grasses and other forage crops can provide dairy farmers with high quality products and different systems of grassland management have been evolved which can influence the rate of growth and quality of grass. Some improvements are claimed for the newer techniques of grass conservation. Allanson[2] singled out haymaking equipment for special attention, and illustrated the factors involved in choosing the best haymaking method by reference to a model of a medium sized dairy farm run by the farmer and one man. About 40 acres of hay yielding about 35 cwt per acre were made annually to feed the autumn calving herd of 30 Ayrshire cows. The farmer was considering whether to add a crimper or a crimper and barn drier to an existing tedder.

Allanson calculated for the ten years 1955 to 1964 the average hay quality and yields associated with the three haymaking techniques on the basis of certain assumptions about the rates of work for the three different techniques and in the light of weather conditions in each period. The average results for the ten year period as a whole are shown below.

TABLE 5

Average hay quality and yields estimated for three haymaking techniques.

10 *year average* 1955-64

	Digestibility of dry matter %	*Hay from* 40 *acres tons dry matter*	*Hay from* 40 *acres at* 85% *dry matter* (tons)
Tedder	55·1	61·4	72·2
Tedder and crimper	59·9	60·5	71·2
Tedder, crimper and drier	65·0	65·3	76·8

The next stage was to design rations incorporating hay of these various qualities and compare the costs and returns from each. It was assumed that the farmer aimed at a herd average of 930 gallons, of which 57 per cent was produced in winter. Rations were calculated only for the average hay quality produced by each technique over the ten years although this put tedders and crimpers in too favourable a light relative to barn driers and took no account of the farmer's aversion to risk. Different quantities of hay and concentrates were required to meet the cows' energy requirements over 165 days; these are shown in Table 6.

TABLE 6

Winter feed required for a 30 cow herd according to technique of haymaking

	Hay	Concentrates
	tons as fed	
Tedder	45·4	23·6
Tedder and crimper	54·1	15·2
Tedder, crimper, and barn drier	66·1	3·8

The three harvesting methods also influenced the quantities of hay available for sale. There were also variations in operating costs, depreciation and interest on capital. These are summarized below:

TABLE 7

Comparative costs and returns from three haymaking techniques

(for a 30 cow farm)

	Tedder £	Crimper £	Drier £
Milk sales at 1964 price levels	4,380	4,380	4,380
Sales of surplus hay at £10 per ton	268	171	107
	4,648	4,551	4,487
Concentrates at £32 per ton	755	486	122
Extra depreciation and interest	—	57	160
Extra operating costs	—	—	121
	755	543	403
Margin	£3,893	£4,008	£4,084
Extra margin over tedder	—	£115	£191
Additional capital needed	—	£250	£1,000*

* Substantial reductions possible.

On the basis of the assumptions made, a farmer with a herd of 30 Ayrshires in the south east would increase his profits by using a crimper and benefit even more if he installed a drier. Furthermore, both hay quality and herd performance would be by far the most consistant with a barn drier, but the final decision would, of course, depend on the farmer's equity position and alternative investment opportunities, despite the attractive returns expected.

Allanson drew the following conclusions from this study:

(*a*) Because it is so important to take the fullest advantage of dry spells in a catchy season, the forecasting services provided by the farmer's nearest weather centre should be used when deciding to undertake haymaking operations;

(*b*) since timing is vital for quality production in wet years, it pays to buy a machine with some reserve capacity;

(*c*) the machine capacity of each technique should be planned as a complete balanced system with all machines at each stage in the system geared to the same throughput;

(*d*) small farmers should think in terms of small manageable plots, only cutting each time the five acres or so that can be handled with the haymaking system employed. Even smaller plots should be cut for barn drying so that the mower is never too far ahead of the baler;

(*e*) farmers using crimpers and barn driers will have to revise their feeding policy in order to take advantage of the better quality hay. More hay will be needed and it might pay to feed different qualities of hay to cows according to their yield as a form of rationing for high quality forage;

(*f*) most of the precautions against weather risks require the use of more expensive machines. The returns from extra capital invested in the dairy enterprise should be compared with the returns from alternative investments which could be made;

(*g*) a wide range of precautions against weather risks are now available in the form of irrigation, different ley mixtures and methods of grazing management and in various conservation techniques such as hay, haylage or silage. The most profitable combination will vary from one area to another according to the local climate and from one farm to another according to herd size and farm circumstances. More guidance in this choice is urgently needed.

2. Profitability Factors

Variations in profits in dairy farming may be the result of deliberate changes in management or policy by the farmers themselves, but on the other hand they can also be influenced by factors over which the farmer has little or no control. The former may elicit studies of motivation, and could be of great practical significance for policy purposes. The latter include natural forces which determine the amount of grass available, the yield and quality of conserved grass products and other crops, as well as the time when livestock must be housed and fed. The impact of these factors is reflected mainly in milk yields, quantities of concentrate feed used, and density of stocking.

Effect of natural conditions

An analysis by Allanson[2] to establish the reason for and extent of differences in incomes between 1960-1961 and 1961-1962 found that 'changes in the average yield per cow and in the amount of concentrates fed appear to have been largely responsible, since the costs of forage production remained the same.' The results are summarized in Table 8.

Table 8

Changes in margin over concentrates per cow between 1960-61 *and* 1961-62*

Relationship of 1961 yield and concentrate levels to those of 1960	Higher margins per cow		Lower margins per cow	
	£10 or more	£10–0	£0–10	£10 or more
	Number of farms			
Higher yields, less concentrates	8	5	—	—
Higher yields, more concentrates	1	11	6	—
Lower yields, less concentrates	1	3	4	2
Lower yields, more concentrates	—	—	1	2

* Constant prices for concentrates at £29 per ton and for milk at 2s. 10d. per gallon.

The data have been set out using constant prices for concentrates and milk for the two years. On this basis it seems that two-thirds of the farmers would have had higher margins per cow in 1961-62 than in the previous year. Thirty per cent managed to get higher yields with less concentrates per cow, and a 'further one in six fed four pounds of concentrates or less for each extra gallon. All systems of milk production and all levels of performance shared in the improvement.' The report then proceeded to examine the weather conditions operating over the two years, and attention was drawn to both the sunshine and rainfall experienced in the critical summer months. It stated that fertilizer and forage costs were the same in the two years. The following tables set out the yields in 1960-62 period as well as the quality of the forage crops over the 1958-62 period.

TABLE 9

Pasture and feed crop yields: Wye, 1960-62

	Grazing wks/ adj. acre		Silage/ adj. acre*		Hay/ acre cut		Feed cereals/ acre		Kale/acre	
	1960 weeks	Difference in 1961 %	1960 cwt	Difference in 1961 %	1960 cwt	Difference in 1961 %	1960 cwt	Difference in 1961 %	1960 cwt	Difference in 1961 %
Good soil	32	+ 6	210	+18	36	− 7	35	−21	291	−18
Weald clay	20	+10	190	+15	39	−30	23	−32	282	−43
Chalk and clay with flints	28	+10	187	+ 8	29	+ 9	24	+18	275	− 6
High Weald (heavy)	28	− 1	235	−12	35	−10	25	− 4	256	−18
High Weald etc., (light)	25	− 6	233	−41	35	− 5	25	−14	300	−43
Average	27	+ 2	216	− 4	34	− 8	25	− 9	271	−23

* Yields per acre cut were half to two-thirds less.

TABLE 10

*Variations in forage quality**: 1958-62

	1958	1959	1960	1961	1962
Silage:					
Proportion of farmers making good silage†	12·2	30·8	10·0	46·5	60·7
Average crude fibre as percentage of dry matter	35·9	32·5	36·1	31·1	29·9
Hay:					
Proportion of farmers making good hay†	5·9	48·4	8·9	67·3	49·3
Average crude fibre as percentage of dry matter	36·4	32·3	35·8	30·7	32·4

* Forage quality from N.A.A.S. samples from south-east England.

† Crude fibre less than 30 per cent of dry matter for silage and less than 32 per cent of hay.

The figures in Table 9 illustrate how yields of pasture and fodder crops vary between years whilst Table 10 gives a clear indication of seasonal variations in the quality of forage; these variations are largely a reflection of annual fluctuations in climatic conditions. In view of this a case can be made for having home-grown feedingstuffs analysed at the beginning of the winter season because it is always possible that some economies can be made in either the price of feed per ton or in the rate of feeding, or that disappointing milk yields can be avoided by changing the composition of the dairy ration. Allanson suggested that many farmers in the south-eastern region were not doing so, and this is evident from the following table.

TABLE II

Hay quality and feed practice: 1963-64 (37 *Low cost production herds*)

Hay quality % digestibility	No. of farms	Distribution of herds according to amount of concentrates fed								Prop. of farmers' estimating hay quality above the level for maintenance
		lb concentrates per gallon								
		Not known	3·0/3·4	3·5/3·9	4·0/4·4	4·5/4·9	5·0/5·4	5·5/5·9	6·0/6·4	
		Number of farms								%
45–49	1	1								0
50–54	7	1		1	2	1	1		1	14 (1* in 7)
55–59	18		1	4	7	3	2		1	11 (2 in 18)
60–64	8		1	3	3	1				25 (2 in 8)
65–69	3			3						66 (2 in 3)

* Accuracy questioned.

(The results from these 37 farms appear to show a normal distribution both of hay qualities and of concentrate usage for any given hay quality, and they also show some slight interaction between hay quality and concentrate usage. This interaction may of course result from the cow's response to nutrients rather than from a conscious policy on the farmer's part. Only the best hay qualities were recognized as such to judge from the farmers' estimates. Obviously a widespread education programme is needed if these farmers are amongst the most cost conscious in the dairy industry).

Allanson questioned whether the general acceptance of variation in yield and quality was justified and suggested that the possibilities of eliminating such variation should be explored. The choice of conservation techniques was one avenue which he investigated.

THE RELATIVE IMPORTANCE OF CERTAIN FACTORS IN PROFITABLE MILK PRODUCTION

Beynon and Langley[6] have also drawn attention to the variation in both the quality and quantity of resources used in farming, and its impact on the physical and financial results of farm businesses. The main objectives of their study were (*a*) to explain the variation in the profits obtained by milk producers and (*b*) to rank the factors explaining this variation according to their relative importance. The basic data used in this work were the results, in terms of gross margin per acre, for 67 dairy herds in the South-west in 1960/61. (Channel Island herds were excluded from the analysis). The results of the analysis showed the association between gross margin per forage acre and five main independent factors—cows per 100 acres (density of stocking), milk yield per cow, price received per gallon of milk, concentrate cost per forage acre, and fertilizer cost per forage acre. Together these five factors were associated with 75 per cent of the variation in gross margins per forage acre. A ranking of the five factors according to their relative importance in explaining variations in gross margins, showed that density of stocking and yield per cow together accounted for the major portion of the explained variation in gross margins per acre, with density of stocking as the outstanding single factor.

In view of the outstanding importance of density of stocking a further analysis was undertaken in order to establish the factors most associated with stocking rate. This analysis revealed that the cost of concentrates per acre, fertilizer costs per acre and yield per cow were each significantly associated with density of stocking but together they failed to explain the major part of the variation in density of stocking. The implication of this might be that increased density of stocking is possible on many dairy farms without accompanying changes in the variables considered in this analysis.

THE INFLUENCE OF SEASONALITY PATTERNS

Dairy farmers are faced with the perennial problem of whether to concentrate on producing low cost summer milk, high priced winter milk or to rely on level production throughout the year. However, as the table below shows, a survey by Sturrock and Silvey[7] of three groups of milk producers in Eastern England in 1961-62 found little difference between the groups in terms of average gross margins per acre.

TABLE 12

Milk production in the Eastern Counties, 1961-62

Type of producer	*Winter* producers*	*Intermediate*	*Summer producers*
% Winter milk	59·7	50·9	43·0
Milk sales (£ per cow)	132·1	122·6	119·5
Variable cost (£ per cow)			
Concentrates	35·0	28·3	31·8
Forage and grazing	9·5	9·7	8·2
Other items	7·4	6·2	5·6
Total variable costs	51·9	44·2	45·6
Gross margin per cow (£)	80·2	78·4	73·9
Acres per cow	1·79	1·78	1·71
Gross margin per acre (£)	44·8	44·0	43·2
Yield per cow (gallons)	916	860	851
Concentrates per gallon (lb)	3·21	2·76	3·00
Number of herds	24	36	11

* Those herds producing at least 55 per cent of their annual total of milk over the October-March period were classified as winter producers. Sturrock and Silvey drew attention to the very wide range of individual results in the three groups and they stated that what mattered most was not so much when to produce, as the methods used to do so. In this survey winter producers showed a range in gross margins from £49 to £108 per cow and from £26 to £61 per acre, and the study attempted to establish some of the reasons for these wide ranges.

The authors pointed out that some factors, such as the price of winter milk, were outside the control of individual farmers, but that others were very much a matter of farmer decision. The most important of these decisions was the feeding practice to be adopted. There were obviously many different systems of feeding dairy cows but they were essentially variations on two basic methods. Either can give good results if efficiently managed. The first depended on moderately high yields and the use of good quality forage as the basis of a low cost ration. The second relied on high yields and heavier, though controlled, levels of concentrate use. The system to be avoided is one with only moderate yields and high feed costs.

The two basic systems are illustrated by the four herds shown in Table 13. These results illustrate the importance of milk yields, the adverse effects of excessive use of concentrates when yields are moderate, and the influence of density of stocking on gross margins per acre.

TABLE 13

Four dairy herds producing winter milk, 1961-62

Level of concentrate feeding	High		Low	
Herds	A	B	C	D
Milk sales (£ per cow)	124·3	148·9	98·9	125·0
Variable Costs (£ per cow)				
Concentrates	45·7	49·6	17·5	21·9
Forage and grazing	11·1	7·7	9·3	9·2
Other items	8·8	−3·5	8·8	7·4
Total variable costs	65·6	53·8	35·6	38·5
GROSS MARGIN PER COW	58·7	95·1	63·3	86·5
GROSS MARGIN PER ACRE (£)	25·6	61·4	34·4	59·7

Level of concentrate feeding	High		Low	
Herds	A	B	C	D
Acres per cow (adj. for aftermath)				
Roots, kale, etc.	0·23	0·36	—	0·10
Hay and silage	0·90	0·29	0·78	0·80
Grazing	1·16	0·90	1·06	0·55
Total acres	2·29	1·55	1·84	1·45
Concentrates fed (lb per gallon)				
Summer	4·19	3·57	0·54	1·45
Winter	5·27	4·99	3·50	2·88
Year	4·81	4·38	2·32	2·40
Yield per cow (gallons)	833	1041	683	851
Cows per herd	37	36	58	102
% Winter milk	57	58	60	66

Herds A and B both used large quantities of concentrates (around 5 lb a gallon in winter and 4 lb a gallon in summer) but the results the farmers achieved were very different. The farmer of Herd B, although a little extravagant, did obtain 1,041 gallons per cow. This paid for the heavy feed bill and left a satisfactory gross margin of £95.1 per cow. Herd A, with a gross margin of only £58.7 per cow, showed the effect of excessive use of concentrates with only a moderate yield of milk, the fault being that rationing was not properly controlled. If cows are overfed, a reduction in the amount of concentrates fed would lead at the worst to only a small reduction in yield, and the saving on the food would offset the loss in yield and give an increase in profit.

Herds C and D ,on the other hand, made more use of bulky fodder; they used less than 2½ lb of concentrates per gallon over the whole year, and hardly any in summer. Costs were low in both herds, but the receipts were very dissimilar. Herd C, with low yields (683 gallons) had a gross margin of only £63.3 a cow whereas Herd D with medium yields (851 gallons) and low costs had a gross margin of £86.5 per cow.

Gross margin per acre is just as, if not more, important as gross margin per cow in assessing the efficiency of milk production. Gross margin per acre over these four farms showed a very wide range, due to the interaction of gross margin per cow and acres utilized per cow. Farms B and D were doing well, whereas Farms A and C were not.

Having illustrated the impact of feeding systems on gross margins, the authors then referred to the relatively low gross margins for rearing young stock and the depressing effect this activity had on gross margins per acre. This was of course particularly important on small farms which could really not afford the luxury of rearing their own replacements.

Finally the study drew attention to the importance of labour and the need to usefully employ labour saved by reorganization of the dairy enterprise if benefit is to be derived. In this study the four farms showed widely varying labour hours per cow. Three of the farms had yard and parlour systems and self-feed silage, but labour varied from 50 to 95 hours per cow. On the remaining farm, cows were milked in a cowshed and were fed hay. Labour used per cow amounted to 137 man hours. In two-man herds improvements in labour utilization effected by changes in layout may enable the same number of cows to be milked by one man. With one-man herds the position is obviously more difficult, and frequently farmers either double their herds or give up milk production. This tendency has resulted in more cows per man, and in future skilled men to cope successfully with this difficult enterprise will be of paramount importance.

Langley[8] has drawn attention to the stability, taking the country as a whole, in the proportion of milk sold in the winter and summer periods. Of the total sales off farms in England and Wales during the period 1951/52 to 1961/62, the proportion sold during the summer months has varied between the narrow limits of 51 per cent and 54 per cent. This stability is also evident in the Milk Marketing Board's Far-West region (Devon and Cornwall), where the percentage summer milk has only varied between 52 per cent and 55 per cent over the same period.

Overall regional figures do conceal the wide variations which occur in the actions of individual producers, and the results of a 10 per cent sample of herds published by the M.M.B. illustrate this in the following table:

TABLE 14

Percentage distribution of herds by seasonality group within M.M.B. Regions.
1959/60*

Seasonality group†	M.M.B. Regions Far West		N.W.	East	North Wales	South Wales	South	S.E.	England and Wales
		‡	Percentage of Herds						
300 and over	4·8	(70)	3·8	2·9	7·6	6·9	1·2	2·8	4·5
250 and under 300	3·6	(65)	3·3	1·9	5·3	6·9	1·6	1·7	3·5
200 ,, ,, 250	10·0	(62)	5·5	6·1	10·7	14·5	4·3	7·0	8·1
150 ,, ,, 200	23·2	(58)	14·9	12·8	21·6	24·8	19·3	18·4	19·6
100 ,, ,, 150	35·0	(52)	33·2	39·3	37·2	33·8	45·2	46·7	38·5
50 ,, ,, 100	21·2	(44)	36·6	33·8	16·4	12·8	27·0	22·7	24·4
Under 50	2·2	(32)	2·7	3·2	1·2	0·3	1·4	0·7	1·4
Total	100·0	—	100·0	100·0	100·0	100·0	100·0	100·0	100·0

* Source: Report of the Production Division, Milk Marketing Board, No. 11, 1960/61. Pages 73–80 with supplement.

† May and June gallons as percentage of December and January gallons.

‡ April to September gallons as percentage of year for each group in Far-West.

Langley pointed out that, by and large, regions with the higher percentage of summer milk producing herds were situated in the wetter grassland areas of the West, and those with the lower proportions were in the drier arable areas of the South and East. The Far-West did not conform to this trend, and the author stated that there may be many factors other than average climatic conditions influencing the pattern of production. Whether this is so or not, a further analysis by the M.M.B. does show a considerable movement of herds from one seasonality group to another. The results for the Far-West region are set out below:

TABLE 15

Change in seasonality group of 1,576 *Herds between* 1958/59 *and* 1959/60* *in the Far-West Region*

Seasonality Group†	Herds which remained in same group Number	%	Herds which changed group Number	%
300 and over	29	25	88	75
250 and under 300	11	13	76	87
200 ,, ,, 250	41	21	153	79
150 ,, ,, 200	121	29	298	71
100 ,, ,, 150	232	44	290	56
50 ,, ,, 100	115	52	108	48
0 ,, ,, 50	4	29	10	71
All Herds	553	35	1,023	65

* Report of the Production Division, Milk Marketing Board, No. 11, 1960/61. Pages 73–80 with supplement.

† May and June gallons as a percentage of December and January gallons.

Between 1958/59 and 1959/60 no less than 65 per cent of the producers moved into a different seasonality category. As Langley points out, 'This suggests that while there is little change in the relative importance of winter and summer milk in the national or regional picture over the longer period, production patterns on individual farms within regions show that a state of change is far more common than one of stability.'

Langley studied a sample of 47 producers with 60 per cent or more of summer milk, situated in Cornwall, Devon and Dorset. When interviewed 29 turned out to be non-intentional summer producers and only 10 produced more than 60 per cent summer milk. Only 18 were summer producers by intention. These 18 producers offered a combined total of 49 reasons for producing summer milk.

TABLE 16

Classification of the 49 reasons given for producing summer milk by 18 intentional summer producers

Type of reason	Number	
(1) *Economic*		
Profitable system	7	
Low cost production	5	
High cost of winter milk	3	
Complementary and supplementary relationships with other enterprises	3	
Preferences for equal monthly cash return	1	19
(2) *Technical* associated with:		
Land and fixed equipment	16	
Milking herd	8	
Feeding and other factors	5	29
(3) *Personal*		
Ill health of farmer in winter	1	1
		49

In explaining the concentration on summer production, technical reasons were far more important than economic ones. Most of the technical points were concerned with landlord's capital; the rest were connected with the management of herds, feeding policies and labour considerations. Only about a quarter of the reasons referred to the profitability of systems of summer milk production. It would seem then that the M.M.B's price policy aimed at making summer production more profitable has not encouraged many producers to change their seasonal patterns of production.

The reasons for producing summer milk by the 10 non-intentional producers with over 60 per cent summer milk are set out in Table 17.

TABLE 17

Reasons why 10 *non-intentional summer producers* (*over* 60 *per cent*) *produce summer milk and their future intentions*

Reason	Number of Producers
Insemination and breeding difficulties:	
(a) will now continue to produce summer milk	3
(b) aim to produce more winter milk	2
Calvings drifted round to spring calving—now content with situation	1
Sold herd and replacements happened to be spring calvers	1
No deliberate policy	1
Rearing beef calves—only surplus milk sold	1
Unaware of the situation	1
	10

Langley proceeded to identify some of the characteristics of 24 producers, eventually classified as summer producers. There were no clear cut features about the sample. These producers concentrated on milk production, and had small to medium sized farms (half the farms were under 100 acres). They were scattered throughout the lowland grassland areas of the south-west rather than situated in any particular locality. The average size of herd was nearly 28 cows with a range from 16 to 43, which seems to support the M.M.B. evidence that there is a tendency for smaller herds to concentrate on summer production. The additional premiums for Channel Island milk, with the high premiums in the winter, tend to make winter milk production relatively more profitable for these breeds. Thus it was not surprising to find only two such herds in the sample. No one soil type was overwhelmingly important. Over 80 per cent of the land was in grass, which, together with other forage crops, was stocked at 1.8 acres per cow, an average figure for dairy farms in the south-west. The peak calving period extended from late March to May, and the average milk yield was 680 gallons per cow ranging on individual farms from 340 to over 1,000 gallons. The average concentrate feeding amounted to 15-16 cwt per cow and 2.5 lb per gallon, which was not a very dissimilar performance to that achieved generally by milk producers in the south-west.

INACCURACIES IN FEEDING CONCENTRATES

Attention has already been drawn (page 7) to the effects of overfeeding of concentrates on the profitability of milk production. Cook[9] dispatched a postal questionnaire on concentrate feeding to 414 farmers included in the National Investigation into the Economics of Milk Production in 1960–62. He obtained an 80 per cent response, weighted in favour of the bigger herds. The farmers were asked (a) how they rationed and dispensed concentrates, (b) what deviations occurred from intended levels of feeding and (c) the extent to which over-dispensing was associated with particular features of the rationing routine.

A very high proportion (95 per cent) of the respondents attempted to ration the concentrates fed according to the yield per cow. The evidence showed that 82 per cent dispensed the intended ration by volume and only 18 per cent by weight. The latter should achieve greater accuracy in rationing. The range in concentrate feeding per gallon revealed by the study is shown in the table below.

TABLE 18

Distribution of herds according to concentrates per gallon (winter period—October to March inclusive)

Achieved ratio per gallon (lb)	*% of farmers*
Under 3 lb	19
3 —3½ lb	14
3½—4 lb	17
4 —4½ lb	14
4½—5 lb	12
Over 5 lb	24
Total	100

The high proportion of farmers feeding more than 4 lb per gallon may be explained by a number of factors. For instance farmers may feed greater quantities to high-yielding cows. Some of the concentrate feeding may be deliberately used to supplement poor quality home-grown fodder crops. Some may be used for steaming up. But, even with such explanations the very large proportion of herds feeding at 4½ lb per gallon and over suggests that there must be unintentional over-dispensing of concentrates, since few would deliberately feed at a higher rate than 4 lb per gallon.

Cook discovered that 'as the proportion of home-grown concentrates in the ration increased so also does the intended feed rate per gallon. Thus, where the home-grown proportion was 33 per cent, the feed rate was 3 lb per gallon, when it was 36 per cent, the feed rate was 3½ lb and at 43 per cent it was 4 lb per gallon.' This is in line with the evidence that whereas only 52 per cent of farmers relying entirely on purchased concentrates fed at 4 lb or more per gallon, 62 per cent of those using mixtures of purchased and home-grown concentrates did so. The study also established the overwhelming popularity of the bowl in dispensing concentrates. It was used in 51 per cent of the herds milked in cowsheds, but naturally, for a much lower proportion of herds milked in parlours.

Attention was drawn to some of the difficulties involved in assessing the degree of deviation from the intended feeding levels. Obviously such factors as the contribution of bulky fodders, concentrates for steaming-up, feeding ahead of yields and difficulties with variations in yields per cow within herds are important. Nevertheless, the performances of 283 farmers were obtained and these have been set out in Table 19.

TABLE 19

Deviation from intended feeding levels for sample of farms

Deviation from intended level	*Number of farmers*	*Per cent*
Exceeding by		
Over 2½ lb per gallon	20	7
2 — 2½ lb	7	3
1½— 2 lb	25	9
1 — 1½ lb	31	11
½— 1 lb	37	13
less than ½ lb	51	18
Falling short by		
less than ½ lb	49	17
½— 1 lb	27	10
1 — 1½ lb	28	10
1½— 2 lb	4	1
2 — 2½ lb	4	1
Total	283	100

The study then examined a number of factors which might exert an influence on the accuracy of concentrate rationing. It failed to find any significant impact exerted by type of buildings, size of herd, type of labour, bonus schemes, time of dispensing, or for that matter volume or weight dispensing. Two features emerged as significant—the utensil used for feeding concentrates and also the use made of home-grown concentrates. The author pointed out that it would be wrong to place the whole burden of responsibility on these two factors, because clearly on some individual farms some of the other features mentioned would be important.

This study was concerned with factors responsible for the failure to feed the level of concentrates deemed appropriate by individual farmers, and as such it was eminently successful. To establish the cost of inaccuracies in rationing is not so straightforward. Although the dangers of serious overfeeding must be avoided, it is quite possible that farmers get a milk response from feeding a bigger ration than intended. If the value of the additional milk more than covers the cost of the extra feed, then additional returns accrue. With underfeeding, adjustment upwards would increase feed costs, and possibly milk sales, but these possibilities do not detract from the study—they merely underline the importance of determining with precision the appropriate ration.

Cook concluded with two points. The first is that on all farms which practice milk recording it should be easy to adjust the total feed for each cow on the basis of an extrapolated yield curve. This would largely rule out errors leading to over-feeding but which might be interpreted as over-dispensing. The second point is that if farmers would make a periodical check of total concentrates used against milk output it would go a long way to draw attention to over-dispensing.

He estimated that the cost reduction which might be effected by accurate rationing of concentrates might amount to as much as 3¼d. a gallon for the winter period. Assuming that the respondents in this study were representative of the dairy farmers generally this is equivalent to a saving of no less than 205,000 tons valued at nearly £5¾ million for the national herd.

INFLUENCE OF BREED ON MARGINS IN MILK PRODUCTION

In view of the increasing interest in Channel Island milk production, Roscoe and Langley[10] extracted and compared the financial results of those Friesian and Guernsey herds which were included in the 1961/62 Milk Cost Investigation carried out in the Exeter Province. The authors set out comparisons of gross margins per cow, per acre and per £100 capital in order to bring out all the advantages and disadvantages experienced on farms using these two breeds.

TABLE 20

Comparison of gross margins for selected breed groups

1961/62

	Friesian	Guernsey	All herds
Number of herds	15	10	48
Average size of herd	37·3	22·2	29·3
Yield per cow (gallons)	842	677	755
Returns per gallon (d.)	33·4	40·7	34·1
Forage acres per cow	1·9	1·5	1·8
Concentrates per cow (cwt)	21·5	19·2	18·9
Concentrates per gallon (lb)	2·9	3·2	2·8
Man-days per cow†	11·8	14·2	12·3
Capital per cow (£)*	80·3	75·0	78·1
Gross Margins:			
Per cow (£)	68·7	58·8	61·3
Per forage acre (£)	35·5	38·4	34·0
Per man day (£)†	5·8	4·1	5·0
Per £100 capital (£)*	85·6	78·5	78·5

† Includes labour on crop production in addition to the direct labour on milking etc. A man-day is equivalent to 8 hours work for an adult male worker.

* Includes capital in cows and dairy equipment, but excludes capital in young stock.

The table shows that the Gross Margin for Friesian herds in the sample was £10 per cow higher than for the Guernsey herds. However, in this sample the greater stocking rate with Channel Island cows gave the breed a higher gross margin per forage acre. On the other hand Friesians showed an advantage both as regards Gross Margin per man day and per £100 capital.

The authors pointed to the differences in the average size of the herds included in the comparison. In order to eliminate the effects of scale, they analysed two groups of herds, all falling within the range of 15 to 40 cows. With the elimination of some large Friesian herds, the differences in the results achieved from the two breeds narrowed considerably.

TABLE 21

Comparison of gross margins for Friesian and Guernsey herds of 15 *to* 40 *cows*
1961/62

	Friesian	Guernsey
Number of herds	9	9
Average size of herd	26·9	23·9
Yield per cow (gallons)	846	675
Return per gallon (d.)	33·5	40·7
Forage acres per cow	1·8	1·5
Concentrates per cow (cwt)	21·1	19·1
Concentrates per gallon (lb)	2·8	3·2
Man-days per cow†	12·5	13·5
Capital per cow (£)*	87·0	74·9
Per Cow	£	£
Gross output	119·3	108·6
Variable costs	58·6	49·9
Gross margin	60·7	58·7
Gross Margins:		
Per forage acre	32·9	39·0
Per man-day†	4·9	4·3
Per £100 capital	69·8	78·3

† and * see footnotes to previous table.

The Friesians still retained their advantage in terms of yield and gross margin per cow, whilst the Guernseys, using only 1·5 forage acres per cow, continued to be superior on the basis of Gross Margin per forage acre.

The authors stated that 'the following overall breed considerations tend to emerge from a comparison of groups of Friesian and Guernsey herds. If buildings and the size of the herds are likely to be factors limiting the size of the enterprise then Friesians show some advantage. If, however, land is likely to be the first factor to set a limit on production, and the objective is to maximize returns per acre, then Guernseys may well be a better choice. Guernseys appear to make relatively good use of capital also but if labour is likely to be a scarce resource, then the evidence indicates a better performance from Friesians.' Attention is, however, drawn to the small number of herds involved in the analysis.

R. O. Wood[11] has also undertaken a study of the performance of Jersey and Guernsey cows in the East Midlands. The investigation was conducted over the period 1962/63 to 1964/65 and the results for the first two years, together with those for 23 Friesian and Ayrshire herds, are set out on p. 24.

This data supports the information from Roscoe and Langley's study. For instance, the average milk yields for the Channel Island Group were considerably below the others, the returns for milk showed an advantage of 6d. to 7d. per gallon, and on average the Group used less forage acres per cow. Costs, however, were rather higher so that the Friesians and Ayrshires showed a marked advantage in margins per cow and per gallon. Wood has not analysed his data on a per forage acre basis, but a calculation on this

TABLE 22

Physical data, costs and returns in the East Midlands for two years, April—March, 1962/63 *and* 1963/64

	24 Channel Islands herds		23 Friesian and Ayrshire herds	
	1962/63	1963/64	1962/63	1963/64
Average number of cows	29·9	32·4	42·4	45·4
Percentage of dry cows	19·6	21·3	17·9	18·0
Yield per cow gallons	699	686	901	891
Labour hours per cow	95	85	74	64
Acres per cow:				
grain and forage	1·95	1·88	2·26	2·03
forage only	1·81	1·71	2·16	1·94
Concs. fed per cow—cwt				
purchased	18·6	17·8	20·6	17·8
home-grown	4·1	4·9	2·1	3·6
Total concs.	22·7	22·7	22·7	21·4
Concs. fed per gallon—lb	3·64	3·71	2·82	2·68

basis shows that the non-Channel Island breeds still retained their financial superiority. It must be pointed out, however, that the differences in herd size is quite considerable and accounts in large measure for the apparent superiority of the Friesians and Ayrshires.

Wood suggested that there was an unsatisfied demand for Channel Island milk in the East Midlands region and considered that increased supplies could only come from existing producers changing their breeds or from new producers. The change-over to the Channel Island breeds is unlikely to take place unless the prospects for profit are as good and preferably better than with Friesian and Ayrshire cows. In order to give a comparison of the two groups, returns and profits were calculated per 24 pence of net cost or approximately one gallon of ordinary milk.

This shows that for an expenditure of 24 pence, the ordinary milk producer obtained a much higher margin than the Channel Island producer. Moreover, he received 3·10 pence more in 1963/64 than in 1962/63 whereas the Channel Island producer received 1·71 pence more.

Wood's study showed that in the East Midlands the cost of producing Channel Island milk was about 9d per gallon or 40 per cent greater than ordinary milk. A number of factors which operated during 1963/64 tended to increase the costs and reduce the profit from Channel Island milk. For

TABLE 22

Physical data, costs and returns in the East Midlands for two years, April—March, 1962/63 and 1963/64

COSTS AND RETURNS	24 Channel Island herds				23 Friesian and Ayrshire herds			
	£ per cow		Pence per gallon		£ per cow		Pence per gallon	
	1962/63	1963/64	1962/63	1963/64	1962/63	1963/64	1962/63	1963/64
Foods:								
Total concs.	32·2	31·6	11·06	11·06	33·3	30·6	8·88	8·24
Total bulky fodders	11·3	11·4	3·89	3·99	15·9	16·0	4·23	4·31
Grazing	8·6	8·1	2·96	2·84	7·7	8·2	2·04	2·19
TOTAL FOODS	52·1	51·1	17·91	17·89	56·9	54·8	15·15	14·74
Labour:								
Paid	14·3	13·7	4·92	4·80	13·3	13·5	3·53	3·64
Farmer	8·1	6·6	2·78	2·31	4·9	4·6	1·31	1·24
TOTAL LABOUR	22·4	20·3	7·70	7·11	18·2	18·1	4·84	4·88
Misc.	18·5	17·9	6·33	6·27	15·6	15·8	4·14	4·26
Herd replacement	5·4	6·1	1·85	2·12	4·6	4·5	1·24	1·22
TOTAL COSTS	98·4	95·4	33·79	33·39	95·3	93·2	25·37	25·10
Less: credit for calves	3·5	3·7	1·20	1·31	7·4	9·0	1·97	2·44
NET COSTS	94·9	91·7	32·59	32·08	87·9	84·2	23·40	22·66
TOTAL RETURNS FOR MILK	118·9	121·3	40·82	42·47	125·6	131·2	33·44	35·31
MARGIN	24·0	29·6	8·23	10·39	37·7	47·0	10·04	12·65
MARGIN plus Farmer's lab.	32·1	36·2	11·01	12·70	42·6	51·6	11·35	13·89

instance, in this particular comparison the size of Friesian/Ayrshire herds averaged 45·4 cows compared with 32·4 for Channel Island herds. Friesian/Ayrshire herds had a yield advantage of 205 gallons per cow, a difference due not merely to difference in management and milk composition but also to differences between the breeds and strains. In addition it seemed that the producers in the Friesian/Ayrshire Group were better managers. The author questioned whether these three factors together were sufficient to account for the 40 per cent difference in costs of production. Indeed despite the wide disparity in costs he suggested that further research was needed before confirmation could be confidently given to the generally held view that, under comparable conditions of environment and management, Channel Island milk costs more per gallon to produce than ordinary milk from Friesian/Ayrshire herds. Furthermore, because of differences in yields and

TABLE 23

Returns and margins per 24 pence net costs

Pence

Item	Ordinary Friesian/Ayrshire group		Channel Islands Guernsey/Jersey group	
	1962/63	1963/64	1962/63	1963/64
Gallons produced for 24 pence	1·03	1·06	0·74	0·75
Returns for milk (d.)	34·30	37·40	30·06	31·77
Margin (d.)	10·30	13·40	6·06	7·77
Increase in return or margin, 1963–64 over 1962–63 (d.)	3·10		1·71	

costs per gallon, price changes alter the relative profitability of Channel Island and ordinary milk. A fall in price improves the position of the former but the reverse occurs with a rise in price.

In terms of total milk solids, the quantity of human food is the same from 700 gallons of Guernsey milk as from 770 gallons of Friesian milk, assuming average composition to be 13·5 per cent and 12·3 per cent total solids respectively. For a price increase of 1½d. per gallon, a 700 gallon Guernsey cow earns an additional 87s., 6d. and a 770 gallon Friesian cow an additional 96s., 3d. per cow. Although precise information on inter-bred yield differences are difficult to procure there is little doubt that the yield advantage of Friesians is considerably in excess of 70 gallons, so that equal price increases per gallon are likely to give Friesian producers an even greater advantage.

The results of this study illustrate how a gallon of Channel Island milk costs more to produce than a gallon of ordinary milk. Higher herd replacement and lower calf credits together with lower yields and higher labour and miscellaneous costs per cow are largely responsible for this. The difference in costs is partly met by the Channel Island milk premium. Recent increases in pool prices have induced a deterioration in the relative position of Channel Island producers and yet the supply has increased as much as can be reasonably expected, bearing in mind the potential for increasing cow numbers and the rate of culling. Wood puts forward the hypothesis of an equilibrium point at which prices and supplies of the two types of milk meet the demand. The prices need not be such that the profits from the two types of milk are the same—indeed it is likely that Channel Island milk production will show lower profits, otherwise there would be a considerable expansion in supplies. In other words, there is a price at which sufficient supplies of Channel Island milk will be forthcoming but, in arriving at this price, due allowance must be made for the differences in the economy of production of the types of milk. Wood considered that this would not be achieved by a common change in price per gallon, and he concludes that a case can be made out for the adjustment of the present price structure of Channel Island milk to maintain a balance with the price of ordinary milk. In particular, he suggests that should demand continue to rise, a relatively greater rise in price of Channel Island milk may be necessary in order to increase supplies.

Allanson[2] has also made a valuable contribution to the volume of information on the performance of Channel Island cows in relation to that of other breeds. He has drawn attention to the fact that inter-breed comparisons are extremely difficult to make, and that crude averages are frequently influenced by variations other than breed. Thus when breed comparisons were restricted to herds under comparable farm conditions at similar levels of management and stockmanship breed differences in the south-eastern survey were not large. This is evident from Table 24.

TABLE 24

Margins over feed costs by breed of cow: 1960–62

	Jersey	*Shorthorn*	*Friesian*	*Ayrshire*
Margin over feed per cow	£60·3	£58·5	£73·3	£78·2
Forage acre per cow	1·5	2·1	1·9	1·9
Margin over feed per acre	£44·0	£28·6	£39·2	£41·8
Output per £100 feed	£222	£233	£212	£277
Average level of management	B	C	B	A

Allanson found that Ayrshires returned the most consistent performance, used the highest proportion of bulk foods, and had high total solids. The Jerseys benefitted from much higher price differentials than in the past, but they appeared to be very vulnerable to wet weather and poor forage quality. Friesians still took some beating, especially with the high prices their beef calves commanded. Finally, Shorthorns had declined in market value to a point where they were beginning to show a useful return on capital.

Allanson also pin-pointed the impact of higher Channel Island premiums. He showed that the higher milk prices tended to compensate for both the lower average yields and the heavier concentrate feeding often found in Channel Island herds.

Success, however, depended partly on the farmer maintaining a winter pattern of production since the Channel Island premium over standard grade milk declined from an average of 7¾d. to 5¼d. per gallon as winter production fell from 56 per cent to 35 per cent of annual production. For winter producers in 1963/64, yields could have been 20 per cent less per cow and concentrates 22 per cent more per gallon and yet the margin over concentrates would have been the same as for Friesians.

He also found that Jerseys had the added advantage of smaller acreage requirements. This fact can tip the scales heavily in their favour or, alternatively, allow even lower yields or heavier concentrate feeding for the same reward per acre. Between herds of the same breed, however, it is said that genetic differences may account for up to 20 per cent of the variation in performance and that the inherent ability of cows to produce milk may be more significant than the intensity of feeding. Sound judgment remains essential, when buying stock, selecting heifer replacements, and also in gauging milk potential when trying to feed to peak yield.

These studies have shown that on average Channel Island cows give lower yields than most other breeds of dairy cows, but the special premiums for which they qualify goes a long way towards overcoming this disadvantage. It is also clear that in these breed comparisons stocking rates have a profound influence on margins earned per acre. The work of Allanson and Roscoe and Langley shows that there is evidence to suggest that the disadvantage of lower yields per cow in Channel Island herds has been largely overcome through higher milk prices and the success achieved in improving stocking rates.

IMPORTANCE OF VARIATION IN YIELD PER COW

There is considerable evidence that milk yield is an important determinant of profitable milk production. It follows that the substitution of higher yielding for low yielding cows would improve the chances of getting higher profits, other things being equal. Hitherto little work had been done on the range of individual yields within a herd, but an analysis of such variation on a sample of 18 herds for the year April 1961 to March 1962 inclusive, undertaken by Marion Slattery[12], represents a step in the right direction.

It was unfortunate that the sample used in this analysis was so small, but this is a difficulty which is invariably encountered when more detailed information is required about differences within farms or herds. The author calculated a coefficient of yield variation for each herd using the formula

$$V = \frac{100\,d}{\bar{x}}$$

where V = the coefficient of yield variation

$\bar{x}$ = the average yield/cow in the herd for 1961/62

d = the standard deviation of the individual cow yields from the mean

She found that there was a significant correlation between increasing yield variation and herd size at the 10 per cent level of confidence, but there was no significant correlation between V and either the herd average yield or farm size. It was expected that increasing variation within the herd in performance per cow would make it more difficult to achieve a high level of general management and feeding efficiency, but an examination of the data caused this hypothesis to be rejected. It was also found that yield variation was not significantly correlated with the profitability of the dairy enterprise.

A management factor that did show a highly significant correlation with the variation in yield was the average number of days per year for which cows in the herd were dry. This was based on the actual days in the twelve months April 1961 to March 1962 for which each animal recorded in the herd was not milking. It appears to be one of the most important causes of a high degree of yield variation and draws attention to the barrier to efficient herd management caused by infertility and disease.

Breed differences did not seem to have a significant effect on yield variation, and none of the other factors tested, including forage acres per cow, the cost of purchased feed per cow in the winter and summer separately and the percentage of cows in winter milk, showed any statistically significant correlation with the yield variation.

The author concluded from these results that the degree of yield variation in any one herd is affected by the size of the herd, and by the average length of the dry period in that herd, particularly the latter. Although the yield variation showed no statistically significant correlation with the profitability of the dairy enterprise, there was some evidence of a negative relationship with concentrate feed utilization. This suggests that some farmers may use heavy concentrate feeding to mask the inherent variation in milking ability among their cows. This is one of the most interesting points to emerge from the study.

Labour use in milk production

Most people agree about the outstanding importance of labour productivity in most lines of production but few have embarked on detailed studies of the factors determining labour/output relationships. This was noticeably so in the farming sector until Cowling[13] analysed data for more than 500 dairy farms in England and Wales. Prior to this study information derived from the National Investigation into the Economics of Milk Production had been subjected only to simple forms of analysis, and this in spite of the fact that labour use is influenced by a number of factors. The availability of computing facilities opened up possibilities of subjecting data to more refined statistical analysis. Such an analysis has been undertaken by Cowling.

The following table based on the results of successive milk costs investigations shows the trend in labour hours used in milk production in the post-war period.

Table 25

Labour and herd size 1947/48 *to* 1961/62

	1947/48	1948/49	1949/50	1950/51	1951/52	1955/56	1956/57	1960/61	1961/62
Average labour hours per cow	158	151	147	142	138	124	118	100	90
Average herd size	27·1	28·0	28·0	28·2	29·1	25·9	26·6	28·5	32·0

It is tempting to infer from the table that increasing herd size has resulted in a decrease in labour hours per cow. This would be an over-simplification because, over the period, there have been quite marked developments in systems of housing, feeding and milking dairy cows, all of which would tend to change the labour input. The labour input does vary with herd size, for instance in 1960/61, farmers with herds of 20–30 cows used 103 hours per cow whereas those with herds of 40–50 cows only used 83. But factors other than size of herd also influence the position, and different systems of producing milk may be the most important of these. Cowling analysed data from the 1960/61 sample, and isolated the net influence of different factors after taking into account the influence of other factors. He tested two main hypotheses, the first that one would expect economies of scale as the size of herd is increased and the second, that labour economies are associated with systems of milk production, with the more efficient system being frequently found in the larger herds. He also investigated the impact of:

number of milking units,
type of milking equipment,
yield per cow per annum,
quantity of roughage fed and
milk recording.

The results of the analyses were as follows:

(i) *Herd size.* This factor in isolation was not an important determinant of labour input, so that within a particular system of milk production, additional cows did not result in a marked economy in labour hours per cow. In other words, using resources more fully was not an important source of economies in labour hours per cow.

(ii) *Average yield per cow per annum.* Cowling found a significant relationship between this factor and total labour hours. The coefficient indicated an increased labour input of 2 hours per cow per annum for an increase in yield of 100 gallons.

(iii) *Milk recording.* The evidence here was somewhat inconclusive but there was a suggestion that milk recording increased the yearly labour requirements per cow by 10–15 hours.

(iv) *Feeding system.* The analyses failed to establish a significant relationship here, but another method of measuring the quantities of roughage fed to dairy cows may be required.

(v) *Housing and milking systems.* With variations in housing and type of milking facilities being combined with a range of numbers of units from two to four or more, a number of different combinations emerged. The least efficient housing on a labour use basis appears to be the cowshed, a system which for an additional cow requires an estimated additional labour requirement of about 100 hours. The labour requirement for the parlour and bail system was considerably lower.

(vi) *Number and type of milking units.* The author pointed out that the estimated effect of number of units on labour efficiency was difficult to approach since the dominant influence was probably the relationship between the number of men and the number of units used. For bucket systems there appeared to be a reduction in marginal labour input with an increase in milking units from 2 to 3, but 4 units, which are usually associated with 2 men, gave no significant improvement.

(vii) *Other factors.* The variation due to other factors accounts for less than 20 per cent of the total variation in labour hours on milk production. Cowling pointed out that the influence of man/machine ratios, distances involved in moving milk and feed, length of winter feeding period as well as work routines could well account for a portion of the unexplained variation. In addition the labour recorded as used on the farm may in fact reflect labour available.

Finally, he stated that 'the major conclusion which can be drawn from the analysis of labour use, is that for the individual farmer who plans to improve his labour efficiency in milk production, changes in system rather than in herd size would seem to be of first importance. Such decisions involve the substitution of capital for labour and must be viewed in the context of the relative scarcity of these resources and of the profitability of alternative uses of his capital.'

MANAGEMENT

Difficulty is invariably experienced in explaining success and failure in all aspects of production but the difficulties are somewhat exaggerated in farming. Allanson[2] considered that in milk production the best guide to managerial ability was the difference between what a herd actually achieved and what might have been reasonably expected of it in the particular conditions under which it was kept. He found that the best managers in the Wye Survey were usually 40–60 years of age. At this stage experience frequently makes up for lack of incentive to make money as people get older and family responsibilities decrease.

Langley[14] has also studied the management factor, and in his report presented the results of an exploratory study of the expectations, adjustments and future production plans of a group of milk producers in the south-west. The study was mainly concerned with how producers see the future, their reasons for making changes and their general behaviour under conditions of uncertainty. It was an empirical study designed to test certain theories of the management process rather than any precise attempt to forecast future milk supplies as such. A questionnaire survey was completed by personal interviews with 40 producers to augment the records already available for these farmers and farm businesses.

The report has three main sections. The first part began with a brief outline of risk and uncertainty in farming and of managerial theory as it is understood at the present time. Risk and uncertainty were defined—the latter representing situations where the outcomes could not be established. Langley reminds us that decision-making under conditions of uncertainty is the task and essence of management. With the time-lag in agricultural production, unpredictable weather and the biological environment, the farmer in particular is faced with problems of resource use when there is incomplete information about the future. The six steps in the decision-making model developed by Professor Glenn Johnson and other agricultural economists in the U.S.A. were set out; these six functions are (1) problem definition, (2) observation, (3) analysis, (4) decision, (5) action, (alternatively execution) and (6) responsibility bearing. The second function, namely, 'observation' was singled out since it is this part of the process that is concerned with the formulation of expectations. The remaining part of the introductory section presented the results of previous research on the types of uncertainty facing the farmer and conceptual material on the nature of expectations.

The second section of this report was devoted to an analysis of the expectations of the individual producers. Particular emphasis was given to price expectations for milk. For dates two and five years hence producers were asked to give (1) 'the most probable price' or the price the farmer considered to be most likely, (2) the 'highest probable price' or the highest price the producer thought there was any chance of receiving and (3) the 'lowest probable price'. The results indicated that nearly all producers were willing to state some opinions on milk prices in two years time. However, while some producers stated their expectations with a great degree of conviction, others found difficulty in formulating an expectation of even the most general nature. An uncertainty rating was developed for each producer but tests of association failed to establish any significant relationships between the degree of uncertainty and certain characteristics of the farmer and his business such as age of farmer, managerial experience of farmer, size of herd, type of farming, and level of net farm income. Some analysis, on the foundations of milk price expectations emphasized the awareness of producers concerning the influence of government action and supply conditions in the industry.

The main analysis of the third and final section of the report was to establish any relationships that existed between milk price expectations and production plans. Producers were asked to anticipate their future herd size in one, two or five years time and also asked for their opinions on the likely trends in yield per cow in their herds. This enabled quantitative estimates to be made of trend in future output.

The author summarized the evidence by stating that 'No association could be established between the level of expected prices and future cow numbers or future milk output, but an association was found between the level of expected milk prices and the level of capital investment. No association could be established between the degree of uncertainty attached to milk price expectations and either ability to state future plans, future cow numbers, future milk output, the level of capital investment or certain other farm adjustments. Producers' answers to direct questions on these relationships appeared to support the above results and also to provide insights into the problem. Many only make specific price expectations and consider prices when making major changes and at these times product price expectations are only one of a number of factors taken into account. Some stated they were conscious of trends but often felt unable to make changes. Others stated that it was the cost of production, and price expectations for inputs therefore, which mainly influenced their farm plans. Although limited data on the influence of the other types of expectations were collected, the study suggested that price expectations for inputs have more influence than product price expectations on plans. Thus while no relationship could be established between milk price expectations and either the choice of enterprise or the level of milk output, the evidence did indicate that both product price and input price expectation influence investment in dairying and, therefore, the methods of milk production.'

Quite obviously, this is a difficult field for research and Langley himself points out that enquiries of this type, partly concerned with the thought processes and related aspects of human behaviour, are subject to many difficulties and it is not easy to establish clear relationships. There is a need for better theoretical models and better methods for empirical research before there will be greater understanding about these areas of the management process.

3. Budgetary Control and Linear Programming

FARM MANAGEMENT has continued to develop over the years, and the technical and economic problems encountered in milk production have received considerable attention. It is natural that the preliminary analyses of a comprehensive set of financial data should progress to a detailed examination of resources used in different enterprises. The application of planning techniques has followed, and a multitude of different approaches have been used. Simple and straightforward budgeting exercises have been reinforced and sometimes replaced with sophisticated techniques using computer facilities. In recent years, enterprise management schemes have been introduced in an effort to persuade the generality of farmers to look more critically at the different enterprises which constitute their total farming activities. This has led to the further refinement of using budgetary control so that adequate checks can be made on the efforts made to achieve appropriate targets. Linear programming, relying on available survey and experimental data, is also being applied to determine profitable systems of production. At Wye the computer has been used effectively to ease the laborious work involved in budgetary control in milk production and, using linear programming, to synthesize grassland dairy systems.

BUDGETARY CONTROL

The Dairy Management Scheme introduced by the N.A.A.S. is designed to help farmers overcome some of the day-to-day problems of feeding dairy cows. This scheme requires that forecasts should be made of milk yields and concentrate input, both of which involve considerable difficulties. Undoubtedly past performance in the individual herd can help, but rapid changes such as increasing herd size, different breeds, changing seasonal pattern of production and varying numbers of cows and heifers, not to mention the inevitable annual fluctuations in quality of forage, can limit the usefulness of the records of previous years.

However, a new control system has been devised (Allanson[15]) to overcome some of the weaknesses of historical information based specifically on the farmer's own herd and the precise conditions under which it is kept. This system enables the margin over concentrates to be forecast for a period of up to nine months ahead and provides for a monthly check on performance throughout the forecast period.

The basis of the recording scheme is:

(a) production forecasts for individual herds based on individual calving dates and lactation averages for cows and heifers in the herd, coupled with average lactation curves provided by the Milk Marketing Board;

Referring to these forecasts, Allanson pointed out that potentially their greatest value to management was that they provided an objective check on whether satisfactory progress was being made towards the planned targets. Obviously adjustments have to be made for incoming and outgoing cows, but thereafter discrepancies from the forecasts should be explained in terms of unpredictable climatic conditions and their effect on forage quality and quantity, as well as unforeseeable difficulties such as herd health. Action can be taken quickly and before the situation has deteriorated too far.

This dairy control system helps farmers with a given pattern of calving, yield levels and forage quality to use available feed as efficiently as possible. It can be adapted to pinpoint the implications of changing patterns of production, yield levels and forage qualities. The need for drastic modification of forecasts will depend on the changes introduced during the planning period and on the accuracy of the forecasts in the first place. Future developments may involve using individual milk yields and weekly forecasts, but Allanson claims that so far, south-eastern experience with the present model has been very encouraging.

LINEAR PROGRAMMING

Allanson[16] has used a linear programme to synthesize grassland dairy systems based on available information from experimental work on grassland and from work carried out in the field of nutrition. He states that the specific aims of his paper are to:

1. Demonstrate one method of synthesizing grassland dairy systems.
2. Establish the extent and limitation of existing knowledge for this method.
3. Indicate some further development which might improve the model.

Dairy farmers find great difficulty in choosing the most appropriate system of milk production for their own particular circumstances. This is not surprising because there is such a wide range of calving patterns, yield levels, grassland species and management practices to choose from. To sort through the welter of possible combinations a hypothetical farm was considered with a hundred acres of grass available for milk production. It was assumed that adequate capital, labour and accommodation were available and that there were no competing claims for land. Assumptions on grass species, fertilizer rates, rates of first growth and regrowth, conservation methods and associated losses, availability of purchased hay (maximum 30 tons) and concentrates, breed of cows, levels of yield, seasonal calving patterns and their different lactation curves, value of calves, and of milk sales according to date of calving were written into the model. Safeguards were taken against inadequate dry matter, energy and protein in the diet.

The model was used to establish (*a*) maximum profit margins over feed costs for herds ranging from 50 to 400 cows for situations where no limit was placed on cow numbers other than nutritional requirements and the availability of suitable feed, (*b*) profit margins at maximum stocking density, (*c*) profit margins at maximum milk production per acre irrespective of the level of concentrate feed and (*d*) profit margin at maximum milk production per acre less 560 gallons of milk for each ton of concentrate fed.

Details of the dairy systems giving the highest margin over feed costs at different levels of stocking are shown below.

TABLE 26

Changes in dairy systems yielding the maximum margins over feed costs as stock numbers increase

Acres per cow	2·0	1·75	1·5	1·25	1·0	0·75	0·5*	0·375	0·313	0·262
Number of cows	50	57	67	80	100	133	200	267	320	382
S24 (acres)	100	100	100	100	100	99·9	71·8	64·6	21·7	—
S37 (acres)	—	—	—	—	—	0·1	28·2	35·4	78·3	100
Concs. per cow (cwt)	2·56	2·40	2·69	10·56	20·87	35·04	50·13	57·20	61·44	65·62
Hay purchased (tons)†	-64·0	-23·5	28·5	29·3	30	30	30	30	30	30
950 *gallon cows*										
October calvers (No.)	15·1	18·5	20·2	25·7	38·9	83·1	197·7	266·7	320	382·2
April calvers (No.)	34·9	38·6	46·5	54·3	61·1	50·2	2·3	—	—	—
Gallons per acre	475	545	633	760	950	1267	1900	2533	3040	3631
Margin over feed costs (£)	5593	6157	6806	7603	8523	9575	11573	13241	14241	15051

* Maximum margin over feed costs.

† Negative values relate to sales of hay.

It is obvious that no data exist to illustrate the possibility of systems operating at extreme rates of stocking and fibre levels might prove inadequate at more than 3 cows per acre. In any case, as Allanson pointed out, non-feed costs in fact would rise faster than returns at stock densities much above one acre per cow in the hypothetical farm situation. Therefore, further particulars of the cropping and feed patterns were given only for the dairy system, yielding the highest margin over feed costs at one acre per cow.

At one cow to the acre, high yielding cows were chosen with 60 per cent calving in the spring. The maximum quantity of 30 tons of hay was purchased. The margin over feed costs was £85·2 per acre and per cow from the following feed system.

TABLE 27

Feed pattern for maximum margins at one acre per cow

	Hay				Dietary concentration for cows calving	
	Digestibility of dry matter (per cent)	Tons fed*	Concentrates (Tons fed**)	Grazing (acres of S24)	October	April
					K cal. per lb D.M.	
Period:						
30 March to 24 April	54 59	9·3 24·2	56·7	—	1177	1182
25 April to 7 June	59	5·1	15·4	—	1182	1250
8 June to 21 June	59	10·5	5·6	100	1000	1182
22 June to 3 August	54	13·1	—	100†	1000	1182
4 August to 13 Sept.	54	2·3	—	100‡	1000	1250
14 Sept. to 25 Oct.	54	5·3	—	100	1000	1250
26 Oct. to 5 Dec.	59	39·7	20·2		1182	1000
6 Dec. to 3 Jan.	59	41·5	0·6		1182	818
4 Jan. to 14 Feb.	59	46·5	6·0		1250	818
15 Feb. to 29 March	59 54	53·7 0·5	—		1182	818

Notes: * At 85 per cent D.M. and after deducting wastage from 262·8 tons bought or made.
** At 85 per cent D.M.

† Production depressed by 20 per cent for 14 days and 41·25 acres grown on for grazing in period 22 June to 3 August.

‡ 6·1 acres grown on for grazing in period 14 September to 25 October.

The implications of some of the management objectives are shown below.

TABLE 28

Comparisons of systems which attain different management objectives

	System maximizing		
	Margins over feed	Milk production	Stock density
	£	£	£
Margin over feed costs:			
per acre	150·5	110·1	51·1
per cow	39·5	27·7	12·3
Yield and calving patterns:		*Number of cows*	
950 gallons October	382·2	—	—
950 gallons March	—	398·3	—
800 gallons October	—	—	236·0
800 gallons March	—	—	180·1
Gallons per acre	3631	3783	3328
Acres per cow	0·26	0·25	0·24

With densities of stocking being pushed to the extreme, cocksfoot replaced rye grass, the maximum quantities of hay were purchased, and between 64·6 and 67·5 cwt of concentrates per cow was fed. In these situations, the maximum permitted dietary concentration was selected in order to rely as much as possible on purchased concentrates. In such situations bulk in forage was favoured rather than quality because forage dry matter becomes a limiting factor.

Table 28 shows that the system maximizing milk production realized only three-quarters of the potential margin over feed costs per acre mainly because milk sales from a spring-calving herd are lower than sales from an autumn-calving herd. This criterion is not concerned with the seasonal level of milk prices.

Profit margins were reduced to one-third of the possible maximum when the highest stocking density was attained because this criterion requires the selection of cows with the lowest feed intake, irrespective of calving date or of the milk produced per unit of feed at different levels of yield.

Allanson outlined further illustrations of the use of programming techniques. For example, the model predicted a maximum production of 590 gallons per acre from grass, after deducting the conventional gallon for every 4 lb of concentrates. This level was achieved with 64 high yielding cows on rye grass leys. Calving was predominantly in the spring and concentrate requirements were 1 cwt per cow. Margins over feed costs per acre fell from £110 to £66 but per cow rose from £28 to £102, compared with the system maximizing milk production without this limitation.

With no purchased concentrates allowance, maximum margins from grass alone fell to £59 per acre and £100 per cow. All but 8 of the 59 high yielding cows calved at the end of March. Protein in winter would be an additional cost.

With a barley yield of 35 cwt per acre and omitting both protein requirements and the potential feed value of the straw, the model showed the advantage of a grass and barley system over an all grass system when purchased concentrates were not available. Maximum margins were obtained from 67 high yielding cows, two-thirds of which calved in the spring. A summary of the three situations is given below:

TABLE 29

Profit margins based on restricted use of purchased concentrates

System	Margin over feed costs per acre £	per cow £	Cows* Total	spring calvers	Leys
Maximum production from grass with deduction for concentrates at 1 gallon for every 4 lb	66	102	64	56	Ryegrass
Maximum production from grass —no concentrates	59	100	59	47	Ryegrass
Maximum production from grass and barley—no concentrates (29 acres Barley)	75	110	67	44	Ryegrass

* High yielding.

The author next considered the impact of economic factors other than feed on profit per acre and profit per £100 capital invested in this hypothetical situation.

TABLE 30

Returns to Land and Capital for different Herd Sizes

	Herd size									
	50	57	67	80	100	133	200	267	320	382
					£					
Margin over costs	5593	6157	6806	7603	8523	9575	11573	13241	14241	15051
Non-feed costs	2525	2732	3050	3455	4075	5475	7625	10260	12425	14277
Profit	3068	3425	3756	4148	4448	4100	3948	2981	1816	774
Capital	10500	11770	13500	15900	19500	25500	37500	50750	60300	71450
Return on capital (%)	29·8	29·2	27·8	26·1	22·8	16·8	10·5	5·9	3·0	1·1
Profits per acre	30·7	34·3	37·6	41·5	44·5	41·0	39·5	29·8	18·2	7·7

Given the assumptions made in this analysis, the maximum profit situation occurred with herd of 105 cows. This involved a stocking rate of 0·95 acres per cow and a milk yield of 1,000 gallons per acre. However, the table also shows that no single rate of stocking had a clear superiority since profits, when expressed in terms of return on capital, declined as profit per acre increased up to the optimal density. The final choice of herd size and dairy system would, therefore, depend on whether land or capital was the more limiting resource.

The following were the conclusions reached by Allanson:

(i) Linear programming can help in the synthesis of grassland dairy systems from experimental data. Cropping, feed, calving and milk yield patterns were determined in the illustrative model.

(ii) The facts and theories about grassland production and dairy nutrition which are available at the present time are not adequate for definitive systems to be developed.

(iii) Uncertainties arising from yield variations due to the weather require even more data if operations analysis techniques are to be applied for their solution.

(iv) In the hypothetical farm situation, the emphasis in grassland management changed from high quality to high bulk as the rate of stocking increased.

(v) A high proportion of first growths was conserved in order to increase production of both dry matter and energy. Species developed specifically for conservation may be worth further consideration.

(vi) No single management criterion is universally acceptable since returns to capital had declined from their highest level before the maximum profit per acre was attained at just under one acre per cow.

(vii) A preliminary exercise indicated that barley production on part of the land might add to profits at the lower rates of stocking.

4. Some National Considerations

MILK SUPPLY RESPONSE

COWLING AND GARDNER[17] have used cross-section data from the 1960–61 National Investigation into the Economics of Milk Production to determine the relationship between milk output on the one hand and feed and other inputs on the other, both with and without allowances for breed differences. Assuming short-run profit maximization within the milk plant, short-run supply curves for milk were generated.

Although in the long run the supply of milk is affected by the stock of cows, their breed composition, and the state of technology and its diffusion in the short run these factors are fixed and the only major response to milk price changes that can be made is to vary the rate of concentrate feeding. The analysis showed that the short run supply was inelastic, that is that over a short time period there is little change in milk supplies in response to changes in the price of milk.

The authors estimated the levels of milk output per cow at various combinations of milk and concentrate feed prices; the results of their calculations are shown below.

TABLE 31

Estimated average milk yield per cow at various milk-feed price ratios (gallons per year)

Price of Milk (pence per gallon)	*Price of concentrate feed (pence per pound of starch equivalent)*							
	3		4		5		6	
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
22	797·82	704·56	729·91	651·87	681·24	613·68	643·89	581·72
30	878·13	765·38	803·39	708·10	749·82	666·63	708·71	632·61
31	887·08	772·11	811·57	714·31	757·46	672·51	715·93	638·25
32	895·84	778·70	819·58	720·42	764·94	678·26	723·00	643·74
33	904·40	785·14	827·42	726·40	772·24	683·87	729·91	649·14
34	912·79	791·44	835·09	732·21	779·40	689·38	736·68	654·39
35	921·01	797·61	842·61	737·92	786·43	694·72	743·31	659·56
36	929·07	803·65	849·99	743·57	793·31	699·99	749·82	664·57
37	936·97	809·58	857·22	748·98	800·06	705·15	756·20	669·53
38	944·73	815·40	864·26	754·35	807·47	710·21	762·46	674·37
39	952·35	821·10	871·29	759·65	813·19	715·19	768·61	679·11
40	959·84	826·72	878·13	764·83	819·58	720·15	774·65	683·79
41	967·19	832·22	884·87	769·91	825·86	724·83	780·59	688·36
42	974·43	837·75	891·48	774·91	832·04	729·67	786·43	692·86

(a) Without breed differentiation.

(b) With breed differentiation and assuming a premium of 6d. per gallon for Channel Island milk.

The quantities in column (b) were obtained by weighting the yield for each breed by the proportionate importance of the breed in the national herd in 1960. The price range for milk and feed was intended to cover all possible price combinations which might be expected in England and Wales in the foreseeable future; in addition the Danish price for milk in 1961–62 (22d. per gallon) was also included. The table shows how changes in the price of milk and cost of concentrate feeds interact to affect average yields per cow. When breed variables were ignored higher average optimal yields were generated.

Cowling and Gardner also estimated the aggregate milk output in England and Wales at various milk-feed price ratios by multiplying average yields per cow by the number of cows recorded for 1960–61. When these estimates were compared with the actual aggregate milk sales in 1960–61 they found that the model which ignored breed differences overestimated the actual quantity, whilst the more technically feasible model which took account of breed underestimated it. The reasons which the authors put forward to explain these discrepancies included the suggestion that producers may base their decisions on the guaranteed price rather than the current realized price, although they thought that this was rather unlikely. Farmers may also be overfeeding in as much as the marginal productivities of feed inputs are believed to be higher than they actually are.

The authors considered the number of cows and their breed composition in their analysis of long-run supply response. They stated that, since June 1953, when the Ministry of Agriculture first distinguished between beef and dairy cows in its statistics, there has been a rising trend in dairy cow numbers but with considerable fluctuations around the trend. An increase in numbers can be brought about by increasing the number of dairy heifers coming into the national herd and/or by reducing the culling rate of dairy cows. Analyses of factors likely to influence intake of dairy heifers and culling of dairy cows emphasized the importance of the fat cow to dairy cow price ratio in determining the size of the dairy herd.

With regard to the influence of breed Table 32 illustrates the changes which have occurred in the composition of the national herd during this century. It shows that the breed composition of the dairy herd has changed during the last half century from being predominantly Shorthorn to mainly Friesian.

The increasing representation of the higher yielding Friesian cows has been partly responsible for the higher average level of milk production per cow in England and Wales. Thus, it may be said that the 1960 composition of the dairy herd would have produced an average increase in milk per cow of approximately 2½ per cent above the 1955 average, merely because of breed changes. In fact, the increase proved to be almost 7½ per cent which means that the average recorded yields of the breeds themselves improved by about 4¾ per cent during the period. These figures referred to milk recorded herds (which are above the national average level of yield), and took no account of annual variations in the composition of the sample, weather conditions and feed intake. The Milk Marketing Board has estimated

TABLE 32

Breed composition of national dairy herd

	1908 %	1935 %	1948 %	1955 %	1960 %	1960 % of Dairy Breeds
Friesian	0	6	32	34	42	51·85
Ayrshire	0	1	11	16	16	19·75
Channel Islands	2	7	9	7	8	9·88
Pure dairy	2	14	52	57	66	81·48
Shorthorn	71	63	34	21	12	14·82
Other	13	10	4	4	3	3·70
Dual purpose	84	73	38	25	15	18·52
Beef	14	13	10	18	19	
Total	100	100	100	100	100	

that between 1955 and 1960 the average milk yield of all cows rose by about 11½ per cent. Thus the yield per cow excluding breed changes, increased by 9 per cent. In other words the non-recorded herds narrowed the gaps between themselves and the recorded herds by improving more rapidly. Whilst part of this is certainly due to improved stock, largely attributable to the influence of artificial insemination, some part may also be due to better feeding and management.

In conclusion Cowling and Gardner drew attention to the possible impact in the future of breed factors on milk yield. In the first place, a modification of breed ratios could take place and further substitution of Friesians for other breeds would raise production significantly. Secondly, the yields of cows in both recorded and non-recorded herds may continue to improve, although the rate of increase may slow down. Finally, technological development and short-run production response to price changes superimposed on breed changes and improved yields might mean an increase in average yield per cow over five years of 6 to 6½ per cent.

REASONS FOR ABANDONING MILK PRODUCTION

Factors inducing movements in the supply of milk in England and Wales have been investigated widely in recent years. In particular, changes in the numbers of registered producers are receiving increasing attention. For instance, Winter[18] carried out an enquiry into this topic in the four northern counties of Cumberland, Westmorland, Northumberland and Durham over the period 1958–62. The investigation was chiefly concerned with:

(*a*) the main reasons put forward by farmers for giving up milk production;

(*b*) the enterprises which have taken the place of milk production in different farming systems; and

(*c*) the effect on farm organization and profits of the changes introduced.

Questionnaires were posted to all farmers known to have discontinued selling milk since 1958. A 50 per cent response rate was obtained, and most of the non-respondents were visited, giving a total of 530 in the sample. Four main categories of reasons were apparent for abandoning milk production:

Group I	Milk production continuing after temporary break, change of title between close relatives, etc.
Group II	Land taken for building or otherwise mainly withdrawn from agriculture.
Group III	Retirement, death or removal.
Group IV	Substitution of other enterprises for milk selling.

The main body of the investigation concentrated on those farms where other enterprises had been introduced in place of milk production. The importance of the four groups are shown below:

TABLE 33

Distribution by counties of farms for which a questionnaire was completed

	Northumberland	Durham	Cumberland	Westmorland	Totals	%
Group I	4	10	10	5	29	5
Group II	9	26	14	3	52	10
Group III	18	36	78	29	161	32
Group IV	83	85	93	27	288	53
TOTALS	114	157	195	64	530	100

The reasons why 288 farmers who abandoned dairying for some other enterprise are listed below. Some farmers gave only one reason for the change whilst others were influenced by two or more considerations.

TABLE 34

Reasons for abandoning milk production for other enterprises

	No. of Farmers stating reasons
A. *Profitability*	
Milk production was losing money	11
Milk production was making very little money	57
Other enterprises were more profitable even though milk production was showing a reasonable margin	32
	100
B. *Inadequacy of Existing Resources*	
Buildings unsuitable for T.T. milk production	121
Shortage of accommodation for workers	4
Part of farm taken for building purposes	8
Unsatisfactory water supply	15
Suitable labour difficult to obtain	83
Disease prevalent in herd	6
Unsatisfactory tuberculin test	8
Milk production unit too small	7
	252

C. *Personal and Social Reasons*

Old age or poor health	30
Dislike of cows	2
Dislike of bureaucratic interference	6
Seven day per week labour requirement	136
Other commitments divorced from the farm	17
	191

D. *Other Reasons*

Contract cancelled	1

By far the most important category was the inadequacy of existing resources with unsuitable buildings and difficulties in obtaining suitable labour together being easily the more important. Winter suggested that the latter reason—difficulty in getting suitable labour—may well be due to the unwillingness of many workers to undertake dairy work and the inability of some to take charge in the absence of the farmer.

It was found that milk production was the main source of income on 249 of the 288 farms where other enterprises had taken the place of milk. And on farms of less than 50 acres—nearly a quarter of the total—milk was the sole source of revenue on many. Here inadequacy of buildings was the main factor compelling farmers to make change, despite the lack of more profitable alternative enterprises.

TABLE 35

Distribution of farms and herds by size on farms where other enterprises had replaced milk production

Size of farm	%	Size of herds	%
20 acres and under	10	Under 10 cows	22·0
21 ,, to 50 acres	13	10 to 19 ,,	33·2
51 ,, to 100 ,,	24	20 to 29 ,,	26·9
101 ,, to 150 ,,	15	30 to 39 ,,	8·8
151 ,, to 200 ,,	15	40 to 49 ,,	3·1
201 ,, to 300 ,,	12	50 to 59 ,,	3·5
301 ,, and over	11	60 to 69 ,,	0·7
—	—	70 and over	1·8
TOTALS	100	—	100·0

Table 35 shows that those farmers who gave up milk production for some other enterprise represented a wide range of farm sizes, but that over 80 per cent of the herds disbanded had less than 30 cows.

The influence of farm size on the nature of the enterprise chosen to replace dairying is shown below:

TABLE 36

Distribution of 274 farms by size of holding and main enterprise replacing dairying

	Substitute enterprise					
Size of holding	Suckling herd	Rearing (other than suckling)	Fattening cattle	Cash cropping	Sheep	Totals
Under 25 acres	—	25	2	1	—	28
25 to 49 ,,	—	21	6	1	1	29
50 to 99 ,,	5	44	11	2	1	63
100 to 199 ,,	16	24	35	5	—	80
200 acres and above	24	8	31	11	—	74
TOTALS	45	122	85	20	2	274

By far the most important activity taken up on the small farms was rearing whereas the bigger farmers introduced or expanded suckling herds, fattening cattle enterprises and, to a lesser extent cash cropping.

The effect of the substitution of other enterprises for dairying on the level of profits on 274 farms is shown in Table 37. It emphasizes the difficulties of small farmers.

TABLE 37

Distribution of farms according to size and change in level of profit

Farm size	Higher profits		Profits about same		Lower profits	
	No. of farms	%	No. of farms	%	No. of farms	%
Under 50 acres	4	6	22	19	38	38
50 to 99 acres	12	20	23	20	31	32
100 to 199 acres	18	29	38	34	24	25
200 acres and above	28	45	31	27	5	5
TOTALS	62	100	114	100	98	100

Few farmers with less than 50 acres managed to secure higher profits as a result of the change from milk—on the contrary about 60 per cent suffered a reduction in profits. But on farms of over 100 acres and in particular those of 200 acres and above, farmers with lower profits were in the minority.

Winter argued that it seems that the number of registered milk producers will continue to fall. While other enterprises may show more attractive returns, farmers will give up dairying for work less demanding on either themselves or hired labour. Only on farms large enough to adopt modern techniques is it likely to be possible to organize shift work. It seems inevitable that many more small farmers will be forced out of milk production through lack of resources, though many would continue if it were possible to replace or modernize existing buildings to T.T. standards.

Finally, the foregoing analysis underlined the well-known substitution position between beef fattening and dairying. Often a switch either way can be made between keeping cows on the yard and parlour system and beef production.

ECONOMIC ASPECTS OF THE QUALITY MILK SCHEME

Following on the report of the Cook Committee and the introduction of the Quality Milk Scheme in England and Wales, Jackson and Silvey[19] presented a paper on the relationship between the net cost of production per cwt of total solids and the percentage of composition. By plotting the mean values for cost per cwt solids opposite the mid-point for class intervals of one quarter of one per cent of total solids (figure), it can be seen that as the percentage composition increases the cost per cwt of solids remains constant at first, then rises. It is appreciated that a large number of factors would influence this relationship. However, in view of the fact that the Cook

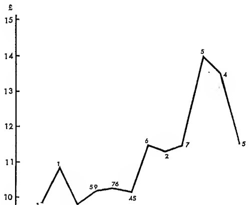

Figure. Cost of production in £ per cwt of total solids and the composition in terms of percentage of total solids. (Figures refer to the number of herds contributing to the mean values.) Sub-sample data.

Committee was disturbed by the decline in the compositional quality of milk, due to the increasing proportion of milk from Friesian-type cows, the authors decided to see if there was any evidence that milk production costs differed according to breed. The mean cost of production was calculated for each breed from a sample of 423 herds and significant differences were found. The results are set out in Table 38.

TABLE 38

Average cost of total solids per cwt by breed

Breed	Ayrshire	Friesian	Guernsey	Jersey	Shorthorn
Cost of production per cwt of total solids (£)	10·17	9·44	11·41	11·67	10·11
No. of herds	105	220	37	28	33

The data suggested that breed might have a significant influence on the relationship between cost and quality. It indicated that among the non-Channel Island breeds the Friesian herds appeared to have a lower cost per cwt of total solids. Statistical tests, however, showed that only in the range of 12·50–12·75 total solids did the Friesians have significantly lower costs per cwt than the Ayrshires. There is only slight evidence, therefore, that Friesians have lower costs per cwt at a given level of total solids. Tests also indicated that the cost of production of solids did not vary significantly between 12·00 and 12·74 per cwt of total solids.

The analyses show that herds with total solids above 13 per cent are almost entirely Channel Island and that their costs per cwt were significantly higher than for other breeds. Since these herds were generally small, the study proceeded to apply regression analysis to see if herd size could be influencing these results. The significant linear regressions derived showed that for the non-Channel Island herds costs per unit of total solids were lower. Therefore, the sample was sub-divided into four herd size groups by breed. Average costs are shown below.

TABLE 39

Average cost per cwt by breed and herd size

Breed	Herd size			
	5–19 cows	20–39 cows	40–59 cows	over 60 cows
Ayrshire	11·13(20)	10·40(27)	9·43(10)	10·57(6)
Friesian	10·73(36)	9·54(53)	9·39(20)	9·45(8)
Guernsey	12·82(11)	11·05(5)	12·25(1)	—
Jersey	12·46(4)	13·00(4)	10·72(1)	—
Shorthorn	11·46(9)	9·60(6)	—	—

The figures in parentheses are the numbers of herds in the sub-groups.

In herds with 5–19 cows there was a significant difference between Friesians and Guernseys, and in herds with 20–39 cows, significant differences were found between Friesians and Guernseys, Friesians and Ayrshires, Shorthorns and Jerseys, and Friesians and Jerseys.

To summarize the results of this study, it seemed that:

(i) for the non-Channel Island breeds there was no statistical evidence that a higher total solids percentage was associated with a higher cost per unit weight of solids within the range of 12·00–12·74 per cent;

(ii) tests between breed means at given range of total solids showed only slight evidence of significant differences in cost per unit of solids;

(iii) within specific ranges of herd size, there were in several cases significant differences between breeds in mean cost of production of solids.

In view of the multiband payments scheme which has been introduced since this report was written, it is interesting to note that, subject to the validity of the assumptions made, the authors conclude that a price policy favouring a level of total solids between 12·50 and 12·74 per cent, rather than 12·00–12·49 should encourage improved milk quality without increasing unit cost of solids since diminishing returns to total inputs are not apparent over the range of solids. They suggest that the evidence does not encourage an extension of quality premium to milk of over 13 per cent total solids.

INVESTMENT IN BULK MILK COLLECTION

One of the most interesting features of the dairy industry in recent years has been the spread of systems of bulk milk collection. Drawing on the experience of farmers with bulk collection facilities, Mitchell[20] has provided information on the relevant issues involved in the decision to install a bulk tank. The fieldwork involved in this investigation was undertaken by members of the Milk Group of the National Agricultural Advisory Service.

The Milk Marketing Board provides assistance to farmers wishing to invest in bulk milk tanks. From 1 April 1966 it has offered loans of up to 70 per cent of the cost of the bulk tank to those farmers who require assistance in providing the initial capital. The loans, plus interest charges, are repayable over three years in thirty-six equal monthly instalments deductable from the monthly milk cheque. Interest is charged to the farmer on the balance of the loan which is outstanding each month at a net rate of 3½ per cent. At the current standard rate of income tax, this is equivalent to a gross rate of approximately 6 per cent. In addition the Board gives premiums for a three-year period to farmers installing tanks. These premiums are considered adequate to provide recoupment of the cost of the tank plus interest charges within three years, provided an average fillage of 65 per cent is achieved. The details of the scheme are set out as follows.

TABLE 40

Premium scale applicable to bulk tanks installed after 1 April, 1966

A. Every day collection

Size of tank Gallons	*Premium* Pence per gallon
150 and under	1·25
151–250	1·00
251 and over	0·75

B. Alternate day collection

Size of tank Gallons	*Premium* Pence per gallon
100 and under	2·00
101–200	1·75

(No alternate day collection for tanks exceeding 200 gallons.)

Government grants in the form of the new Farm Improvement Scheme and investment incentives, worth together 30 per cent of the cost of bulk milk tanks, are also available.

Mitchell calculated the maximum prices which farmers could pay for tanks, assuming 65 per cent fillage, if they were to recover the total costs from premium receipts and Government grants within three years. His results are set out below.

TABLE 41

'Break-even' and other prices corresponding to an average tank fillage of 65 per cent

Size of tank	'Break-even' price	Government grant	M.M.B. loan	Interest* on loan	Repayment to M.M.B.	Premium receipt
gallons	£	£	£	£	£	£
Everyday collection						
80	388	116	272	25	297	297
100	485	146	339	32	371	371
110	533	159	374	34	408	408
125	606	183	423	40	463	463
150	727	218	509	47	556	556
175	678	203	475	44	519	519
200	776	234	542	51	593	593
240	931	279	652	60	712	712
250	969	291	678	63	741	741
300	873	263	610	57	667	667
350	1018	306	712	66	778	778
400	1163	348	815	75	890	890
500	1454	436	1018	94	1112	1112
Alternate day collection						
80	310	93	217	20	237	237
100	388	116	272	25	297	297
110	373	112	261	24	285	285
125	424	127	297	27	324	324
150	509	153	356	33	389	389
175	594	178	416	38	454	454
200	679	204	475	44	519	519

* 6 per cent p.a.

The table shows the maximum prices for each size of tank. They have been called 'break-even' prices because if the farmer pays more he will not recover his total outlay within the premium period; if he pays less premium receipts will exceed his total repayments to the M.M.B.

'Break-even' prices should be regarded primarily as a means whereby investment in bulk collection can be compared with investment in other activities for they enable the net capital cost of installing a tank to be readily calculated. This net cost is the difference between the purchase price of the tank and its 'break-even' price. Having calculated this sum, the farmer can then decide whether its investment in bulk collection or in some other use would bring the greater financial return (excluding premium receipts) or non-monetary reward. The decision should not turn solely on whether or not a tank can be purchased at, or below, its 'break-even' price. With this use in mind, a ready-reckoner was prepared (Table 42) showing for each size of tank the 'break-even' price which corresponds to a given rate of fillage.

TABLE 42

'Break-even' tank purchase prices

Size of tank	Average percentage tank fillage								
	45%	50%	55%	60%	65%	70%	75%	80%	85%
gallons	£	£	£	£	£	£	£	£	£
Everyday collection									
80	268	298	328	358	388	417	447	477	507
100	336	373	411	448	485	522	560	596	634
110	369	410	451	492	533	574	615	656	697
125	420	467	513	560	606	652	699	745	792
150	503	559	615	671	727	783	839	895	951
175	469	521	574	626	678	731	783	836	888
200	537	597	657	716	776	836	895	955	1015
240	645	716	788	859	931	1003	1074	1145	1217
250	671	746	820	895	969	1044	1119	1193	1268
300	604	671	739	806	873	940	1007	1075	1142
350	705	783	862	940	1018	1096	1174	1253	1331
400	805	895	984	1073	1163	1253	1342	1432	1521
500	1007	1119	1231	1342	1454	1566	1678	1790	1901
Alternate day collection									
80	214	238	262	286	310	333	357	381	405
100	268	298	328	358	388	417	447	477	507
110	259	287	316	345	373	401	430	459	487
125	294	327	359	392	424	457	489	522	555
150	352	391	431	470	509	548	588	627	666
175	411	457	503	548	594	640	686	731	777
200	469	522	574	627	679	731	784	836	888

Similarly, Table 43 enables the 'break-even' percentage fillage corresponding to any tank purchase price to be readily calculated. For example, if a 150 gallon tank, for alternate day collection, is purchased for £600, 'break-even' percentage fillage is 600 x ·128 per cent, i.e., 77 per cent. If this tank is filled to 65 per cent of its capacity, its net cost to the purchaser is £600–509, i.e., £91.

TABLE 43

'Break-even' percentage fillage per £1 of tank purchase price

	Size of tank (gallons)	Fillage (£)
Everyday collection	80	·168
	100	·134
	110	·122
	125	·107
	150	·089
	175	·096
	200	·084
	240	·070
	250	·067
	300	·075
	350	·064
	400	·056
	500	·045
Alternate day collection	80	·210
	100	·168
	110	·174
	125	·153
	150	·128
	175	·109
	200	·096

It is obviously to the advantage of the farmer to fill the tank as full as possible but a number of factors seem to influence the extent to which total capacity can be used. An analysis was carried out to show the effect of (*a*) maximum monthly fluctuation (highest monthly milk sales as a percentage of average monthly sales), (*b*) tank capacity per cow (nominal total capacity divided by the number of cows in the milking herd) and (*c*) yield per cow as the independent variables on percentage tank fillage. Maximum monthly fluctuation did not significantly affect percentage tank fillage. It was found, however, that tank capacity per cow and yield per cow together accounted for 88 per cent of the variation in percentage tank fillage. The following formula may be used as a guide to the most appropriate tank for different size of herds and yield of cows:

$$E = \frac{F}{4\cdot180 - 0\cdot063A + 0\cdot430D}$$

Where A = per cent tank fillage
D = yield per cow ('00 gallon)
E = herd size (cows)
F = tank size (gallons)

Mitchell claimed that discussion of the relationship of premium payments to the expenditure on the farm tank alone is inadequate since the change to bulk collection frequently involves additional expense of a capital nature, e.g., from the widening of a farm gateway to the erection of new buildings. For instance, in a sample of 47 farms, only six had been able to install tanks without having to meet other costs as well. Some of the remaining 41 farmers incurred expenditure on electrical wiring, widening of doorways and gates and renovating roads; others built new milk rooms or made extensive alterations, and a few erected new buildings or modernized existing ones. It is obvious, therefore, that anyone contemplating the installation of bulk tanks needs to consider the full ramifications involved.

The report also contained comparisons of bulk handling and churn handling times and it was shown that a high proportion of the farmers who participated in the labour inquiry believed that they had reduced labour costs by bulk collection. This information, together with data on interest charges, percentage fillage and premium receipts, enables farmers to determine the profitability of this technique of milk handling. The report showed that only two farmers in a sample of 25 gave expectation of higher profits as the main reason for introducing a tank, but 19 expected the system to be more profitable. However, 21 farmers, i.e., 84 per cent, introduced bulk collection firmly believing that they would recover the capital cost of the tank within the initial period. The fact that a very high proportion of the farmers are unlikely to regret the financial outcome of their decision suggests that an acceptable level of profitability is not difficult to achieve. This ties in with the high proportion of farmers with experience of bulk tank operating, who did not think that they could have obtained greater satisfaction, either profit or some other benefit, if they had invested the capital in a different way.

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